Runoff Estimation for Sizing Culverts in Eastern Montana

by

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ABSTRACT:

Culverts for small drainage basins typically are designed based on peak flows estimated from the regression analysis given by Omang (1992). These culverts often appear to be unreasonably large when compared to the historic performance of smaller culverts in similar locations. The goal of this study is to provide an improved technique for estimating runoff from small drainage basins in Eastern Montana. A multi-variate regression analysis is performed on drainage areas of less than one square mile in an attempt to obtain improved peak flow estimates. The effects of upstream storage on culvert discharge, and thus culvert design, are demonstrated by fitting a synthetic storm hydrograph (Craig, 1978) to a peak flow estimate and performing flood routing calculations on two example culvert design problems.

Regression analysis shows that maximum one-hour rainfall is a useful basin parameter for predicting peak flows from small drainage areas. Example problems demonstrate that upstream storage can have a much larger effect on calculated culvert size than variance in the peak flow estimate. Hydraulic analysis accounting for upstream storage yields reasonable culvert sizes based on the historical performance of the culverts being replaced. Hydraulic analysis based only on a peak flow estimate yields larger culvert sizes that do not appear to be justified.

INTRODUCTION:

One of the duties of the Hydraulics Section of the Montana Department of Transportation is to size culverts for highway crossings. In order to determine an appropriate size, an estimate of runoff from the upstream drainage area is necessary.

The peak flow regression equations developed by the USGS (United States Geological Survey; Omang, 1992) are the most widely used method for sizing culverts in ungaged drainage areas. These equations were derived from measurements at 522 gaged drainage areas that range from 0.04 to 2,554 square miles. Based on the historical performance of highway culverts, the Department of Transportation feels that these equations overestimate flow values for drainage areas at the lower end of this range.

This goal of this study is to reconcile the discrepancy between calculated culvert size and the satisfactory historical performance of culverts deemed "undersized" by the USGS method. This is accomplished in two steps: (1) Perform a multi-variate regression analysis on small drainage basins relating peak flow to precipitation and basin parameters, and (2) recommend an established synthetic hydrograph technique, allowing the designer to account for upstream storage when choosing a culvert size.

Regression equations for peak flows from drainage areas of less than one square mile are developed and compared to the published USGS equations. Using a log-linear regression model, the independent variables found to be significant are: basin area, maximum one-hour rainfall, and average annual precipitation. The one-hour rainfall information used in the regression analysis is the result of a statistical analysis of actual NOAA (National Oceanic and Atmospheric Administration) one-hour rainfall data. All other data used in the regression analysis have previously been published by the USGS.

By combining a storm hydrograph with site data relating water surface elevation to storage and culvert discharge, the effects of upstream storage can be calculated using a flood routing procedure. The effects of upstream storage can dramatically reduce the flow that a culvert must actually pass. Basing culvert design on this reduced outflow instead of the peak storm flow allows a smaller, less expensive culvert to be specified. Peak flow information from regression analysis can be combined with the synthetic hydrograph method developed for use in Wyoming (Craig, 1978) to generate a synthetic storm hydrograph. Unfortunately, the drainage basins in this study have only peak flow data available, making it impossible to compare synthetic storm hydrographs to actual stream flow data.

Two example problems from an actual road construction project are solved to demonstrate methodology. These solutions illustrate that for small drainage areas the effects of upstream storage on calculated culvert size can be far more significant than effects related to variance in peak flow estimates from different

calculation methods. Culvert sizes calculated from hydraulic analysis, including upstream storage, are similar to the sizes of the existing culverts that have performed satisfactorily at the sites for many years. Similar analysis, but with upstream storage effects neglected, yields larger culvert sizes that do not appear to be necessary and are significantly more expensive.

REGRESSION ANALYSIS:

This study is limited to drainage basins of less than one square mile in the plains of Montana, east of the continental divide. Large runoff events from small drainage basins in this part of the state are typically caused by intense, localized thunderstorms. For a storm with a given return interval, the highest peak flow from a drainage basin will be produced when the duration of the rain storm equals the time of concentration. It is assumed that the time of concentration for the small drainage basins in this study is less than one hour. The shortest duration (and therefore highest intensity) rainfall records widely available in Montana are one-hour records. These one-hour rainfall data most accurately represent the intensity of the thunderstorms that cause large peak flows from the drainage areas included in this study. Because one-hour rainfall data are not available in a useable form for regression analysis, it was first necessary to collect and analyze the existing data using statistical methods.

For each hourly rain gage in Eastern Montana, the maximum recorded one-hour rainfall was collected for every year the gage was in operation. The NOAA one-hour rainfall records through 1990 as published by Earth Info on compact disc were the data source. From these data, rainfall intensities with return intervals of 2, 5, 10, 25, 50, and 100 years were estimated for each of the 78 gages with at least 10 years of record.

The rainfall intensities for each return interval were calculated by fitting Gumbel's extreme value distribution (Haan, 1977) to the rainfall record for each station.

$$P(x) = e^{-e^{(\hat{\beta}-x)/\hat{\alpha}}} \qquad (1)$$

$$\text{where: } \hat{\alpha} = \frac{s}{1.283} \qquad \hat{\beta} = \bar{x} - 0.45s$$

s=*sample standard deviation;* $\bar{x}$=*sample mean*

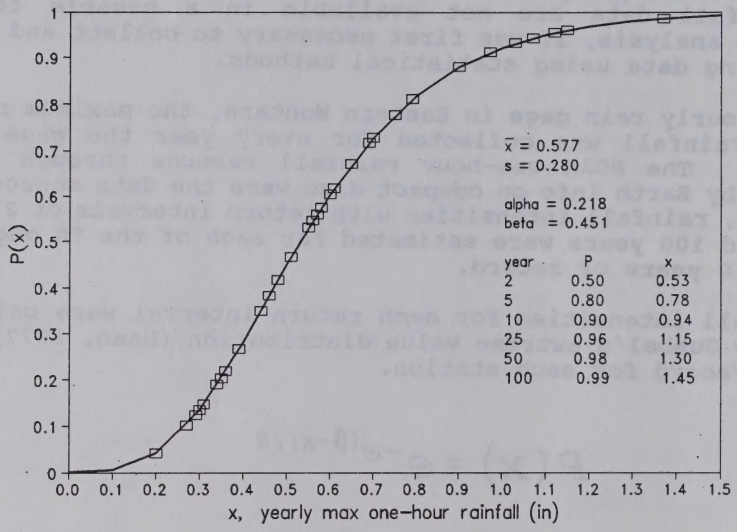
P(x) is the probability that the maximum one-hour rainfall for a given year will be less than or equal to x inches. Solving for x:

$$x = \hat{\beta} - \hat{\alpha} \ln(-\ln P) \qquad (2)$$

Where P = 0.50, 0.80, 0.90, 0.96, 0.98, and 0.99 for the 2, 5, 10, 25, 50, and 100 year events, respectively. For example, the 100-

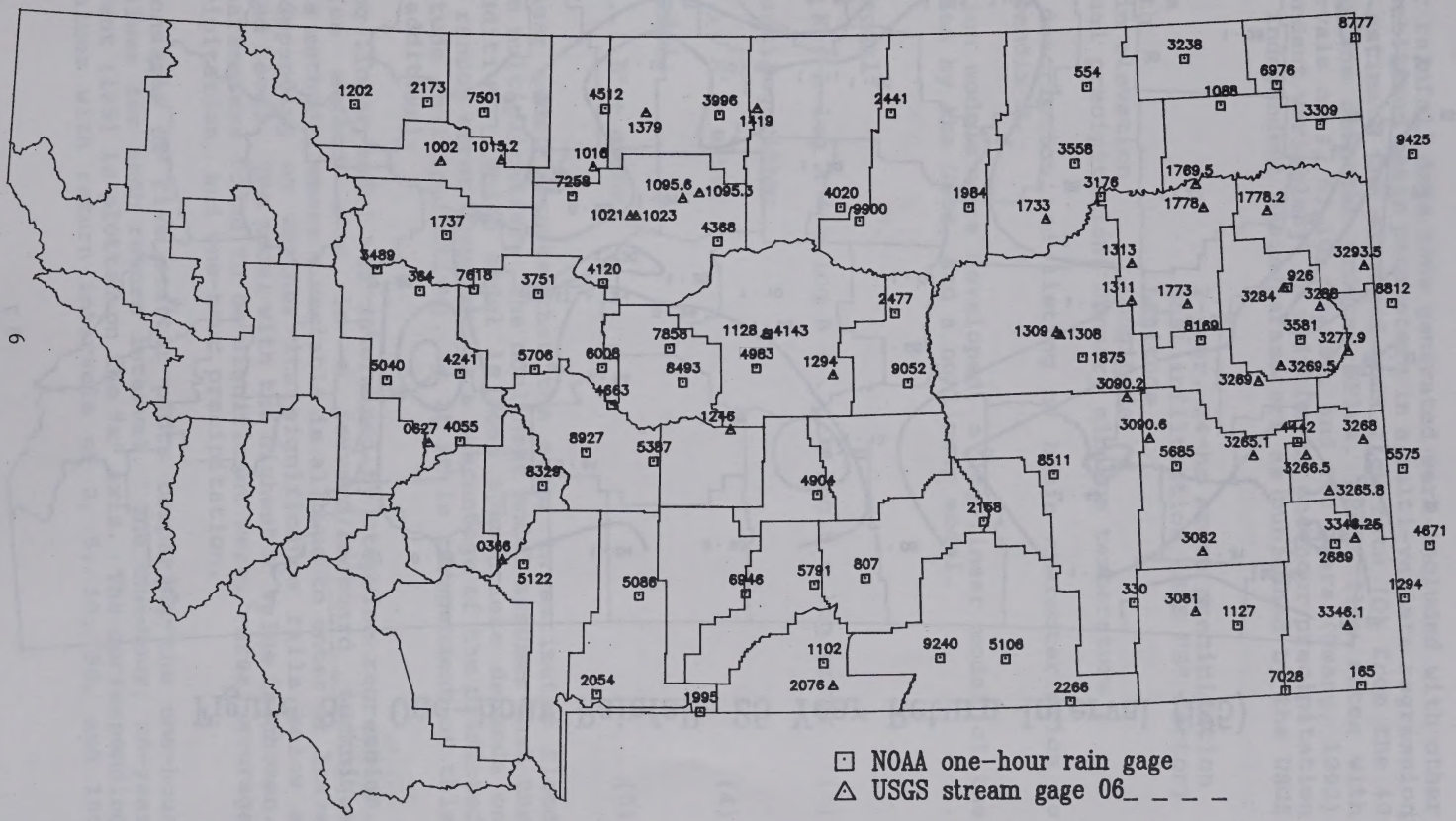
year rainfall event has a 1 in 100 chance of occurring during any given year. Therefore the probability of a given year's rainfall being less than or equal to the 100-year event is: P = 1 - 1/100 = 0.99. The rainfall data and results of these calculations are in Appendix C. Figure 1 graphically represents the results from the Alzada, Montana rain gage. The open boxes represent the probability assigned to each year's maximum one-hour rainfall using Gumbel's distribution.

Figure 1; Alzada, rain gage MT 165



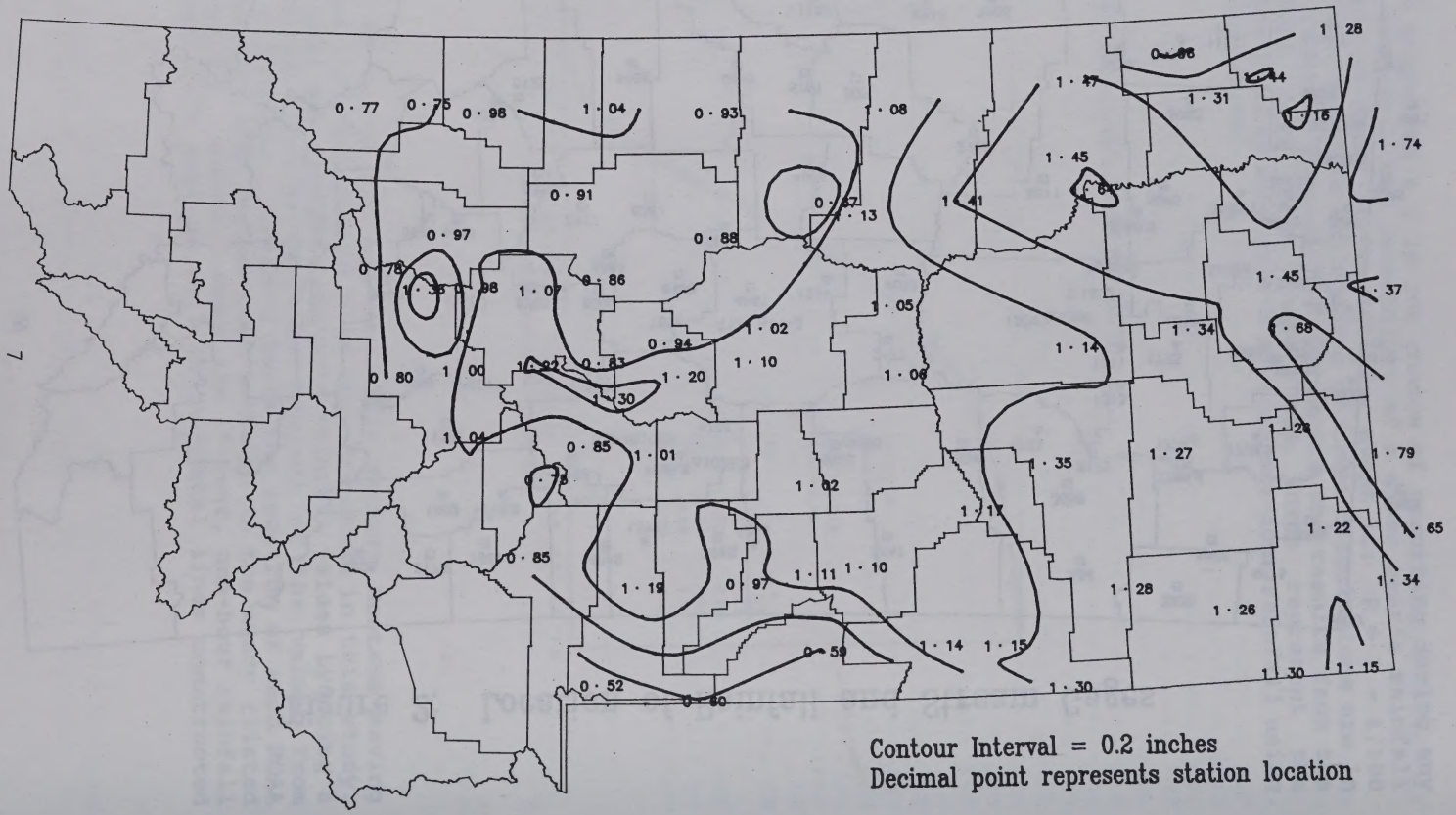
Each of the 40 gaged drainage basins in Eastern Montana having areas of less than one square mile were included in this study. Each stream gage was assigned one-hour rainfall values by using a weighted average (inverse distance squared) of the values from surrounding rain gages. Figure 2 shows the location of each NOAA rain gage and each USGS stream gage included in the study (listed by station number). Figure 3 shows the 25-year, one-hour rainfall value for each rain gage as well as isohyetal lines constructed therefrom.

Figure 2; Location of Rainfall and Stream Gages



□ NOAA one-hour rain gage
△ USGS stream gage 06_ _ _ _

Figure 3; One-hour Rainfall, 25 Year Return Interval (i25)



The one-hour rainfall data thus generated were included with other previously published basin parameters in a multi-variate regression analysis to estimate the expected peak flow rate (Q) from the 40 basins using the computer program SPlus. Peak flow rates with return intervals of 2, 5, 10, 25, 50, and 100 years (Omang, 1992) are the dependent variables. In addition to one-hour precipitation values, the independent basin parameters as published by the USGS are:

Basin area	2-year, 24-hr storm precipitation
Stream slope	Soil infiltration (SCS "S" factor)
Stream length	Latitude
Average basin elevation	Longitude
Average annual precipitation	January minimum temperature

A complete description and listing of basin characteristics is given in Appendix B.

Two regression models were developed, a log-linear model of the same form used by the USGS, and a nonlinear model.

Log-linear model:

$$\log Q = \log K + a \log A + b \log B + \ldots n \log N + \log \text{error} \quad (3)$$

Taking the antilogarithm:

$$Q = K A^a B^b \ldots N^n * \text{error} \quad (4)$$

Nonlinear model:

$$Q = K A^a B^b \ldots N^n + \text{error} \quad (5)$$

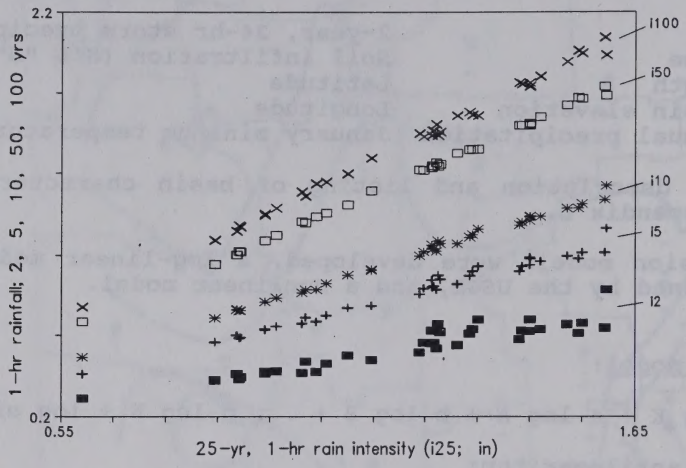
The log-linear model assumes that the error in estimated flood magnitude is multiplicative. The nonlinear model assumes that the error is additive. Which model is most appropriate depends on whether the random error component is a percentage of the predicted flood magnitude (multiplicative), or if it is independent of this magnitude (additive).

The best log-linear model was determined by stepwise regression. The stepwise method used is a forward/backward technique (Efroymson's method), where a variable is allowed to enter or leave the model depending on whether its significance falls below a predetermined level. The model with the highest R^2 value is chosen. The basin parameters found to be significant were: area, average annual precipitation, and one-hour precipitation.

Figure 4 consists of five scatter plots comparing the one-hour rainfall values for each return interval. The one-hour, 25-year rainfall event (i25) is plotted on the "x" axis. The corresponding one-hour values with return intervals of 2, 5, 10, 50, and 100

years for each stream gage are plotted on the "y" axis. There are 40 points plotted for each return interval, one point for each stream gage. The strong linear patterns for all of the one-hour rainfall values show that these variables are highly correlated to each other.

Figure 4; Scatter plots



One might expect the return intervals of rainfall intensity (i) and flood magnitude (Q) to match each other in a regression equation (Q2 uses i2, Q5 uses i5...). Because the one-hour rainfall variables are highly correlated, it is mathematically equivalent to use the same one-hour rainfall return interval for every flood return interval, and modify the exponents accordingly. Comparison of R^2 values from log-linear regression shows that using the one-hour precipitation values with return intervals of 25, 50, or 100 years statistically gives the best results regardless of the return interval of the peak flow being estimated. Almost all of the rain gages used to develop the intensity variables have been in operation less than 50 years. Thus it was decided the 25-year values have the highest practical significance, these are used in the final model. This provides a simpler model that is as accurate as using matching return intervals.

The best log-linear model from stepwise regression was used as the initial estimate for nonlinear optimization. The constants in each equation were modified to minimize the sum square of the error in the arithmetic, not log, scale. Log-linear and nonlinear models are compared in the following section.

Discussion of regression analysis:

Three models are now available for predicting peak flood flow from the drainage basins in this study. They are: (1) the log-linear equations published by the USGS, (2) the log-linear equations from this study, and (3) the nonlinear equations from this study. The new log-linear and nonlinear equations are given in Appendix A.

It is not a trivial problem to choose the best model from the three alternatives available. The statistic R^2 was used to select the best fitting model while doing log-linear regression, but R^2 cannot be used to compare the log-linear model to the nonlinear or the USGS models. R^2 measures the quality of fit of a linear relationship, it does not apply to the nonlinear model. The drainage basins in this study are in six different USGS hydrologic regions, therefore the USGS peak flow estimates are the results of six different sets of regression equations. R^2 measures how well a single linear equation fits a set of data, a single R^2 value representing how well a combination of six equations fits the data cannot be calculated.

It was decided to compare each model three different ways. The first and second comparisons used are the variables $|E|$, and E^2, defined in equations 6 and 7. $|E|$ and E^2 compare absolute error and error squared in the arithmetic scale (smaller errors indicate a better predictive model). The third method of comparison is to subjectively examine residual plots for each model (figures 5 - 7) and the actual model output in Appendix A. Each residual plot has 40 points, one for each drainage basin. Points to the right of the 45° line represent an underestimate of the observed value. Points to the left of the 45° line represent an overestimate of the observed value. A perfect fit would have all of the points plotted on the 45° line.

$$|E| = \frac{\Sigma |Q_{est} - Q_{obs}|}{\Sigma Q_{obs}} \qquad (6)$$

$$E^2 = \frac{\Sigma (Q_{est} - Q_{obs})^2}{\Sigma Q_{obs}} \qquad (7)$$

Figure 5; Residual plots, USGS equations

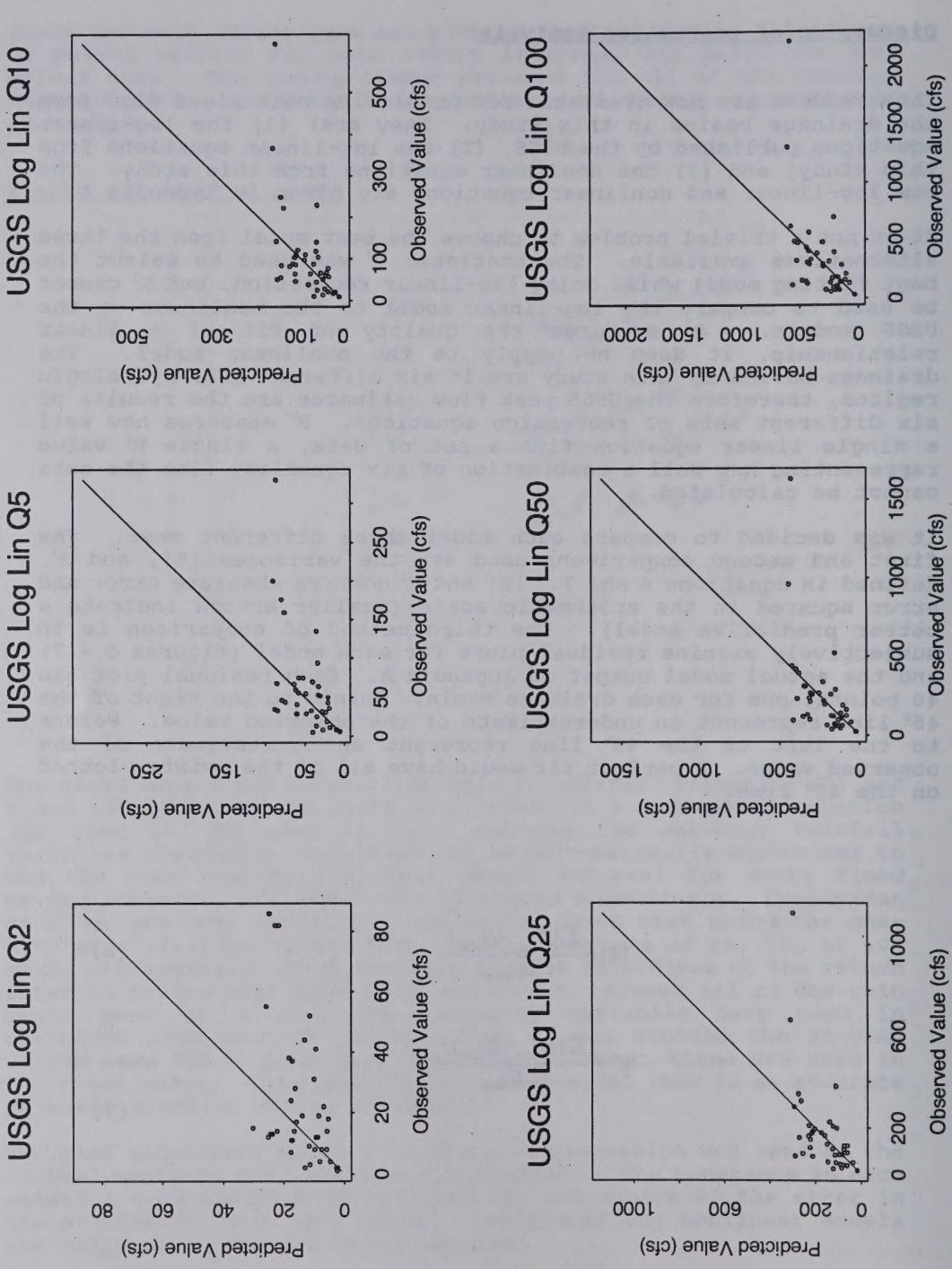


Figure 6; Residual plots, log-linear equations

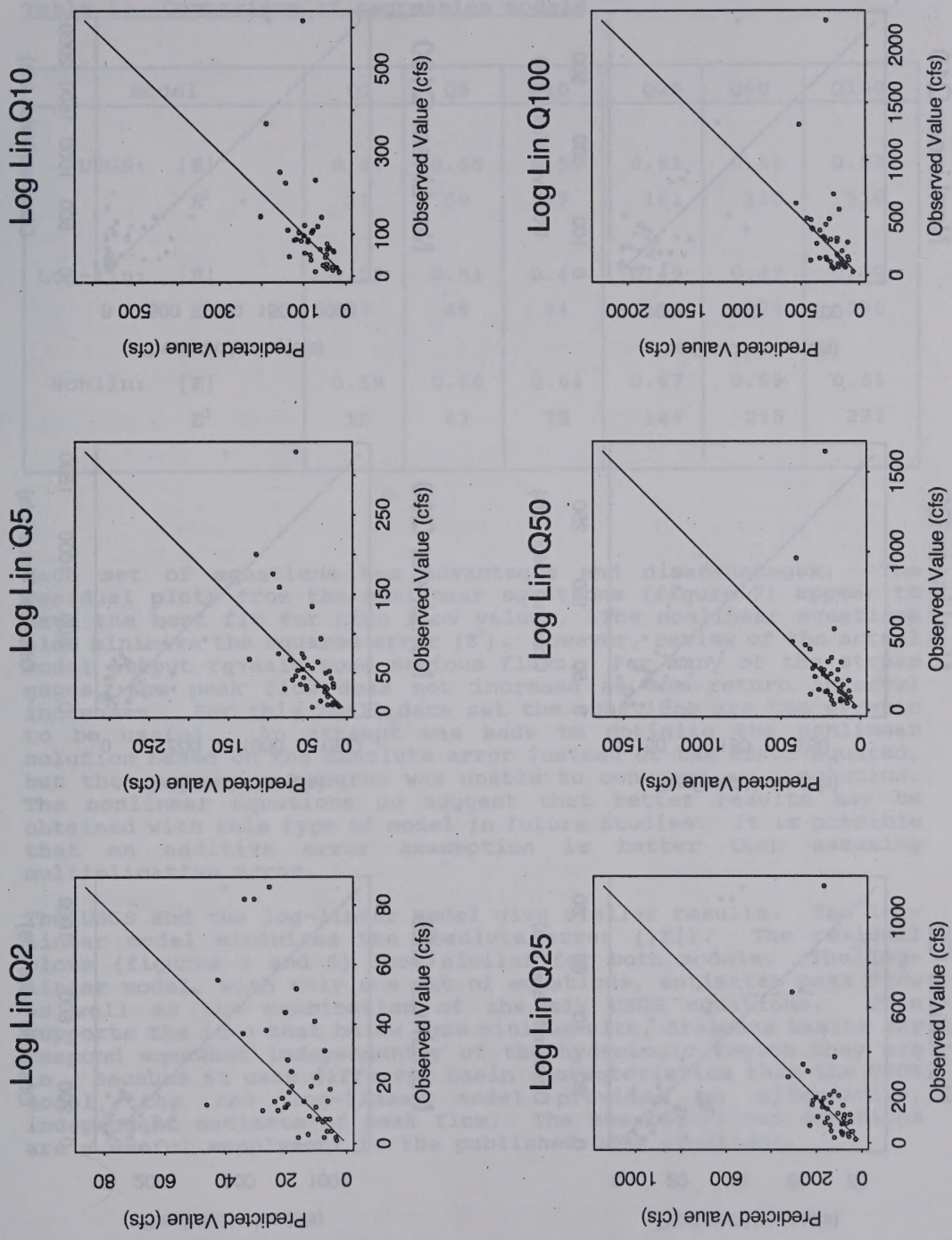


Figure 7; Residual plots, nonlinear equations

Table 1; Comparison of regression models

Model		Q2	Q5	Q10	Q25	Q50	Q100
USGS:	$\|E\|$	0.64	0.55	0.53	0.51	0.51	0.52
	E^2	21	50	87	161	230	318
Log-lin:	$\|E\|$	0.57	0.51	0.49	0.49	0.49	0.50
	E^2	17	49	94	185	276	390
Nonlin:	$\|E\|$	0.59	0.60	0.64	0.67	0.69	0.61
	E^2	15	47	75	144	215	222

Each set of equations has advantages and disadvantages. The residual plots from the nonlinear equations (figure 7) appear to have the best fit for high flow values. The nonlinear equations also minimize the squared error (E^2). However, review of the actual model output reveals some serious flaws. For many of the stream gages, the peak flow does not increase as the return interval increases. For this small data set the equations are too erratic to be useful. An attempt was made to optimize the nonlinear solution based on the absolute error instead of the error squared, but the regression program was unable to converge on a solution. The nonlinear equations do suggest that better results may be obtained with this type of model in future studies. It is possible that an additive error assumption is better than assuming multiplicative error.

The USGS and the log-linear model give similar results. The log-linear model minimizes the absolute error ($|E|$). The residual plots (figures 5 and 6) look similar for both models. The log-linear model, with only one set of equations, estimates peak flow as well as the combination of the six USGS equations. This supports the idea that below some minimum size, drainage basins may respond somewhat independently of the hydrologic region they are in. Because it uses different basin characteristics than the USGS model, the new log-linear model provides an alternative, independent estimate of peak flow. The new log-linear equations are a useful supplement to the published USGS equations.

Regression analysis final results:

The following equations are the final result of the log-linear regression analysis.

$$Q2 = 2{,}442\ A^{0.6986}\ p^{-1.9916}\ i25^{2.3244}\ ;\quad R^2 = 0.40 \qquad (8)$$

$$Q5 = 17{,}539\ A^{0.6357}\ p^{-2.3436}\ i25^{2.0561}\ ;\quad R^2 = 0.44 \qquad (9)$$

$$Q10 = 51{,}964\ A^{0.6154}\ p^{-2.5528}\ i25^{1.8896}\ ;\quad R^2 = 0.44 \qquad (10)$$

$$Q25 = 112{,}176\ A^{0.5937}\ p^{-2.6276}\ i25^{1.6507}\ ;\quad R^2 = 0.42 \qquad (11)$$

$$Q50 = 148{,}559\ A^{0.5724}\ p^{-2.5958}\ i25^{1.4537}\ ;\quad R^2 = 0.38 \qquad (12)$$

$$Q100 = 198{,}244\ A^{0.5569}\ p^{-2.5800}\ i25^{1.2582}\ ;\quad R^2 = 0.35 \qquad (13)$$

where:

Qi = peak flow rate for the i^{th} year return interval in years (cfs)
A = area (mi^2)
p = average annual precipitation (in)
i25 = 25-year, maximum one-hour rainfall (in)

Annual precipitation values are from the SCS document Average Annual Precipitation Montana (1977). Values for i25 are from figure 3.

The forms of the equations seem physically reasonable. Peak flows are directly proportional to area and one-hour precipitation and inversely proportional to annual precipitation. Areas with higher annual precipitation generally will have a thicker, more established vegetative cover that more effectively impedes runoff.

HYDROGRAPH ANALYSIS:

At many highway stream crossings, ponding behind highway embankments temporarily stores flood waters. The effect of this temporary upstream storage is to reduce the peak flow at the culvert. The reduced flows permit the installation of smaller, less expensive culverts. To account for storage effects when designing a culvert, an estimate of the entire flood hydrograph, not just the peak flow, must be made. In addition, information describing how storage volume and culvert outflow vary with water elevation must be known. Storage volume can be estimated from topographic maps, culvert outflow can be calculated from the appropriate hydraulic equations. An outflow hydrograph can be computed by combining stage, storage, and culvert outflow information, and then applying the continuity equation to the pond directly upstream of the culvert (i.e., by flood routing).

Continuity: Inflow - Outflow = Rate of change in storage (14)

Topographic information required to estimate upstream storage is often readily available from highway construction project maps. Unfortunately very little storm hydrograph data are available in Montana for small drainage basins. The drainage basins in this study only have peak flow data, making it impossible to develop a synthetic hydrograph technique from actual stream flow data. However, it is possible to combine the peak flow information from regression analysis with an established synthetic hydrograph technique to provide the runoff information needed to perform a flood routing analysis.

The USGS and the Wyoming Highway Department conducted an extensive study of storm hydrographs from small (0.69 - 10.8 square miles), semiarid, drainage basins in the plains of Wyoming (Craig, 1978). The Wyoming plains have a climate similar to Eastern Montana, and the emphasis on small drainage basins with ephemeral streams makes the Wyoming study a very good hydrological match for the basins in this study. Although other techniques are available, it is beyond the scope of this paper to rigorously determine the most appropriate hydrograph method for the state of Montana.

The Wyoming hydrograph technique has been adapted for use on the drainage basins in this study. Developing a storm hydrograph is very straight-forward using this method. First, peak flow is calculated from the regression analysis results of this study or the published USGS equations. Runoff volume is estimated from the peak flow, using an equation from the Wyoming study that may be used when there is no runoff volume data available. The estimated peak flow and runoff volume values are then fitted to a dimensionless hydrograph to create the final storm hydrograph. Steps are as follows:

(1) Calculate peak flow rate (Q) using the appropriate equations from regression analysis.

(2) Calculate runoff volume using: $V = 0.131\ Q^{0.878}$

Peak flow (Q) is in cfs and runoff volume (V) is in acre-ft. This relationship was developed using 105 hydrographs from 35 different drainage basins in the Wyoming study. The correlation coefficient is 0.90 and the average standard error is 55%.

(3) Calculate curve fitting constants Q', V', and T' (Q is in cfs and V is in acre-ft).

Q' = Q/60
V' = V/970
T' = 726*V'/Q'

(4) Compute the actual points of the storm hydrograph, t and q, from the dimensionless hydrograph defined by t' and q'.

t = t'T' t is time in minutes
q = q'Q' q is discharge in cfs

Dimensionless hydrograph		Synthetic storm hydrograph	
t'	q'	t (min)	q (cfs)
0	0	0 * T'	0 * Q'
3	5.6	3 * T'	5.6 * Q'
5	13	5 * T'	13 * Q'
7	25	7 * T'	25 * Q'
10	49	10 * T'	49 * Q'
11	57	11 * T'	57 * Q'
12	60	12 * T'	60 * Q'
13	59	13 * T'	59 * Q'
14	55	14 * T'	55 * Q'
18	38	18 * T'	38 * Q'
23	23	23 * T'	23 * Q'
30	12	30 * T'	12 * Q'
40	5.2	40 * T'	5.2 * Q'
50	2.0	50 * T'	2.0 * Q'
60	0.5	60 * T'	0.5 * Q'
70	0	70 * T'	0 * Q'

EXAMPLE PROBLEMS:

Two culvert design problems supplied by the Montana Department of Transportation were worked using the techniques developed in this study. The storage indication curve method is used to route the inflow hydrograph. Only the basic design steps and results are shown, the reader may refer to Hydraulic Design of Highway Culverts (FHWA, 1985) for more detailed information on culvert design.

The drainages selected are from the project RS 401-1(1)0, located north of Laurel, Montana. As part of road improvements, the old culverts will be replaced. A hydraulic analysis must be performed, showing that the new culverts installed will prevent the 25-year storm from overtopping the road.

Table 2; Culvert design data

Station	340	347
Drainage area (mi^2)	0.09	0.49
Inlet invert elevation (ft)	3999.9	3993.1
Overtopping elevation (ft)	4003.7	3999.0
New pipe length (ft)	90	115
New pipe slope (ft/ft)	0.030	0.023
Existing culvert	18" CSP*	18" CSP*

* corrugated steel pipe

1. Calculate Q25 and storm hydrograph constants.

For both sites: p = 14 in; i25 = 1.1 in.

Station 340

$Q25 = 112{,}176(0.09)^{0.5937}\ (14)^{-2.6276}\ (1.1)^{1.6507} = 31$ cfs
$V25 = 0.131(31)^{0.878} = 2.7$ acre-ft

$Q' = 31/60 = 0.52$
$V' = 2.7/970 = 0.0028$
$T' = 726(0.0028)/0.52 = 3.89$

time to peak: $tp = 12(3.89) = 47$ min

Station 347

$Q25 = 112{,}176(0.49)^{0.5937}\ (14)^{-2.6276}\ (1.1)^{1.6507} = 84$ cfs
$V25 = 0.131(84)^{0.878} = 6.4$ acre-ft

$Q' = 84/60 = 1.40$
$V' = 6.4/970 = 0.0066$
$T' = 726(0.0066)/1.40 = 3.42$

time to peak: $tp = 12(3.42) = 41$ min

Note: Using the published USGS regression equations: Q25(340) = 11 cfs; Q25(347) = 40 cfs. Use the larger values calculated from the new regression equation in the analysis.

2. Estimate available upstream storage.

Upstream storage volume was estimated by using a planimeter to measure the area enclosed by the relevant contour lines on five foot contour, 1"=100', topographic maps (figures 8 and 9) prepared by the Department of Transportation from aerial photos. Volume was calculated as the average area enclosed by adjacent contours multiplied by the contour interval. Enclosed areas for elevations between contour lines was estimated by linear interpolation. These calculations are shown with the storage indication curve data in step 4.

Storage available at overtopping:

station 340 = 107,700 ft^3
station 347 = 240,600 ft^3

Figure 8; Topographic map, station 340

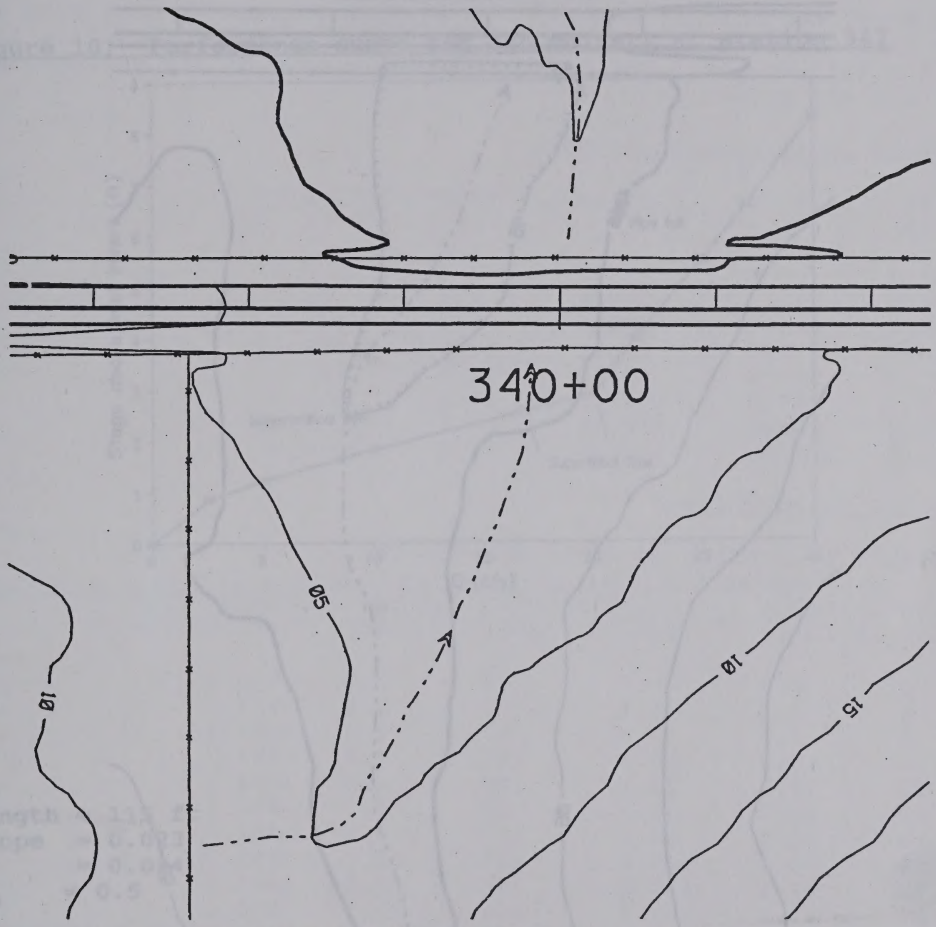
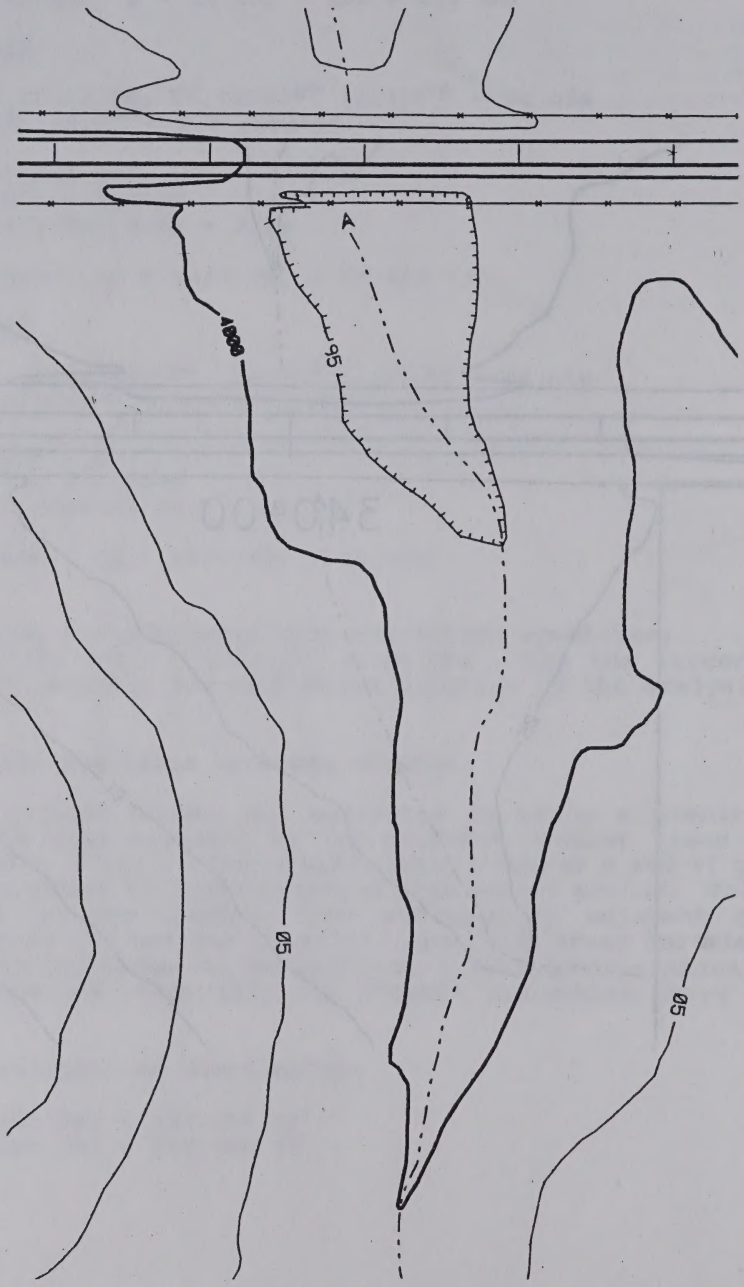


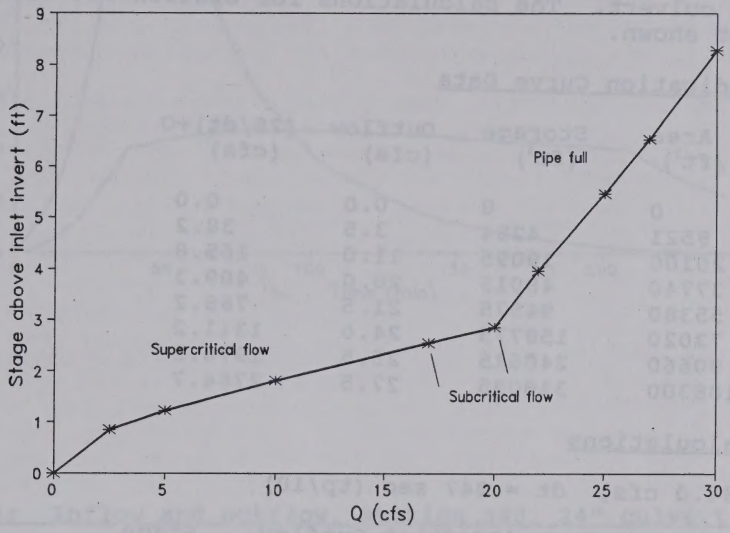
Figure 9; Topographic map, station 347



3. Develop culvert performance curves.

The following performance curve was developed for station 347 using open channel and pipe hydraulics formulas.

Figure 10; Performance curve for 24" culvert at station 347



Length = 115 ft
Slope = 0.023
n = 0.024
k_{ent} = 0.5

Road overtopping effects are not shown.

4. Develop storage indication curve and perform routing calculations.

Routing calculations are based on the continuity equation, expressed as:

$$I_1 + I_2 + (2S/dt + O)_1 - 2O_1 = (2S/dt + O)_2 \qquad (15)$$

where dt, the routing interval, is typically taken as one-tenth of the time to peak. The following calculations are for station 347 with a 24" culvert. The calculations for station 340 are similar but are not shown.

Storage Indication Curve Data

Stage (ft)	Area (ft^2)	Storage (ft^3)	Outflow (cfs)	(2S/dt)+O (cfs)
3993.1	0	0	0.0	0.0
3994.0	9521	4284	3.5	38.2
3995.0	20100	19095	11.0	165.8
3996.0	37740	48015	20.0	409.3
3997.0	55380	94575	21.5	788.2
3998.0	73020	158775	24.0	1311.2
3999.0	90660	240615	25.5	1976.2
4000.0	108300	340095	27.5	2784.7

Routing Calculations

Q peak = 84.0 cfs; dt = 247 sec (tp/10)

time (min)	Inflow q (cfs)	I_1+I_2 (cfs)	(2S/dt)+O (cfs)	Outflow (cfs)	Stage (ft)	
0	0.0	---	0	0.0	3993.1	
4	3.1	3.1	3	0.3	3993.2	
8	6.3	9.4	12	1.1	3993.4	
12	10.9	17.2	27	2.5	3993.7	
16	17.2	28.1	50	4.2	3994.1	
21	26.6	43.8	86	6.3	3994.4	
25	37.2	63.8	137	9.3	3994.8	
29	50.7	87.9	206	12.4	3995.2	
33	64.1	114.8	296	15.8	3995.5	
37	77.6	141.7	406	19.8	3996.0	
41	84.0	161.6	528	20.5	3996.3	(peak inflow)
45	81.5	165.5	653	21.0	3996.6	
.	.	.	.	.	.	
.	.	.	.	.	.	
.	.	.	.	.	.	
82	30.0	63.0	1197	23.4	3997.8	
86	27.4	57.4	1208	23.5	3997.8	(peak outflow)
90	24.7	52.1	1213	23.5	3997.8	
95	22.1	46.8	1212	23.5	3997.8	

Figure 11; Inflow and outflow, station 347, 24" culvert

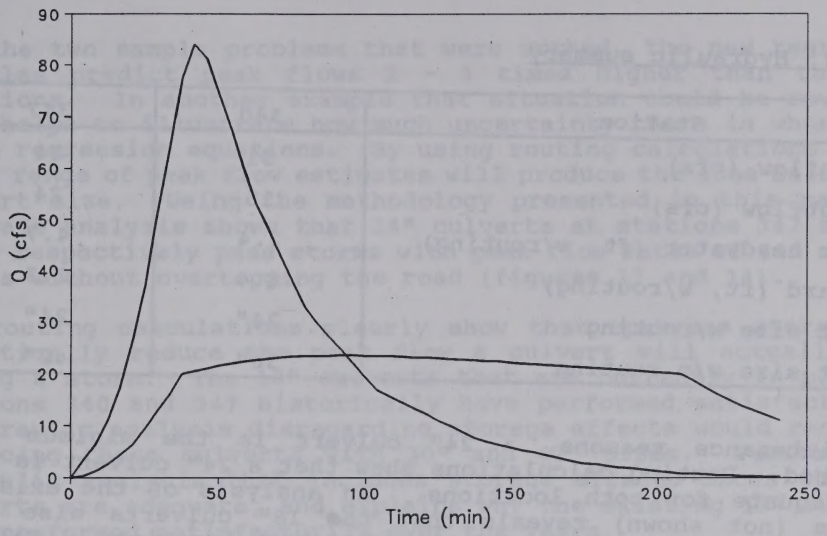
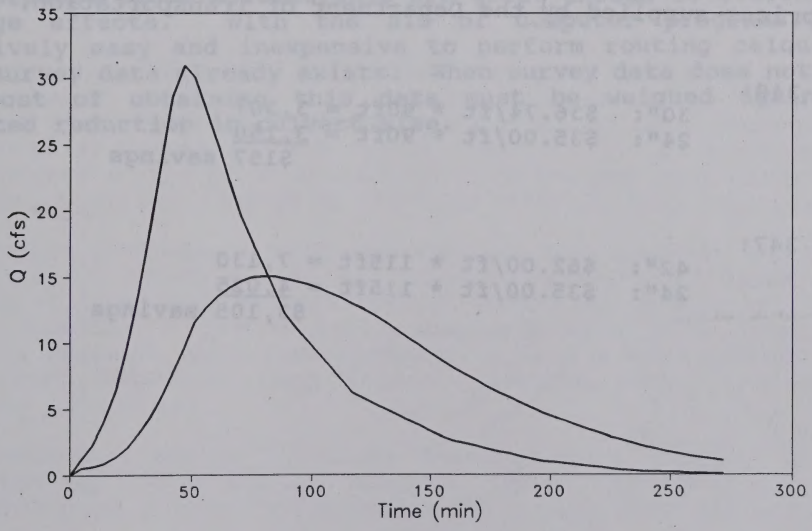


Figure 12; Inflow and outflow, station 340, 24" culvert



5. Culvert selection and cost comparison.

Table 3; Hydraulic summary

Station	340	347
Peak inflow (cfs)	31	84
Peak outflow (cfs)	15	24
Maximum headwater (ft, w/routing)	2.4	4.7
Freeboard (ft, w/routing)	1.4	1.2
Culvert size w/routing	24"	24"
Culvert size w/o routing	30"	42"

For maintenance reasons, a 24" culvert is the minimum size considered. Routing calculations show that a 24" culvert is more than adequate for both locations. An analysis of the existing culverts (not shown) reveals that the 18" culverts also will prevent the road from being overtopped at both locations. Culvert sizes without routing were determined by calculating what culvert size was necessary to pass the peak inflow with a headwater that would not overtop the road.

Cost Comparison

A rough cost estimate was made for each location using current (1994) prices supplied by the Department of Transportation.

Station 340:

30": $36.74/ft * 90ft = 3,307
24": $35.00/ft * 90ft = 3,150
$157 savings

Station 347:

42": $62.00/ft * 115ft = 7,130
24": $35.00/ft * 115ft = 4,025
$3,105 savings

Discussion of sample problems:

For the two sample problems that were worked, the new regression formulas predict peak flows 2 - 3 times higher than the USGS equations. In another example that situation could be reversed. This helps to illustrate how much uncertainty there is when using these regression equations. By using routing calculations a much wider range of peak flow estimates will produce the same calculated culvert size. Using the methodology presented in this paper, a separate analysis shows that 24" culverts at stations 347 and 340 could respectively pass storms with peak flow rates of 125 cfs and 67 cfs without overtopping the road (figures 13 and 14).

The routing calculations clearly show that upstream storage can dramatically reduce the peak flow a culvert will actually pass during a storm. The 18" culverts that are currently in place at stations 340 and 347 historically have performed satisfactorily. A hydraulic analysis disregarding storage effects would recommend replacing these culverts with 30" and 42" pipes. Performing a hydraulic analysis that includes storage effects shows that 24" culverts are adequate, and explains why the existing 18" culverts have performed satisfactorily over the years.

At station 347 there is a significant savings in construction costs by using the culvert size calculated with the routing procedure. At station 340 the cost savings are minimal because of minimum culvert size requirements. These examples suggest that routing calculations can justify the use of significantly less expensive culverts at some locations and not at others. Very small drainages will be controlled by minimum size requirements, large drainages will produce flood volumes that are great enough to overwhelm any storage effects. With the aid of computer programs, it is relatively easy and inexpensive to perform routing calculations when survey data already exists. When survey data does not exist, the cost of obtaining this data must be weighed against the expected reduction in culvert size.

Figure 13; Station 347, 24" culvert

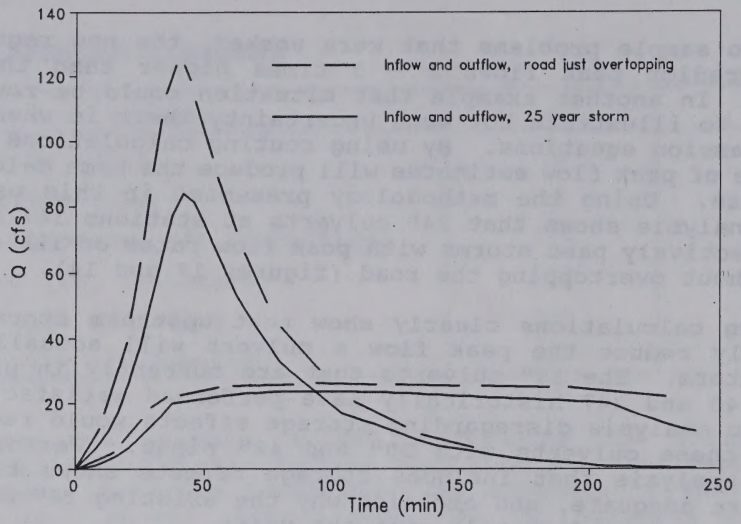
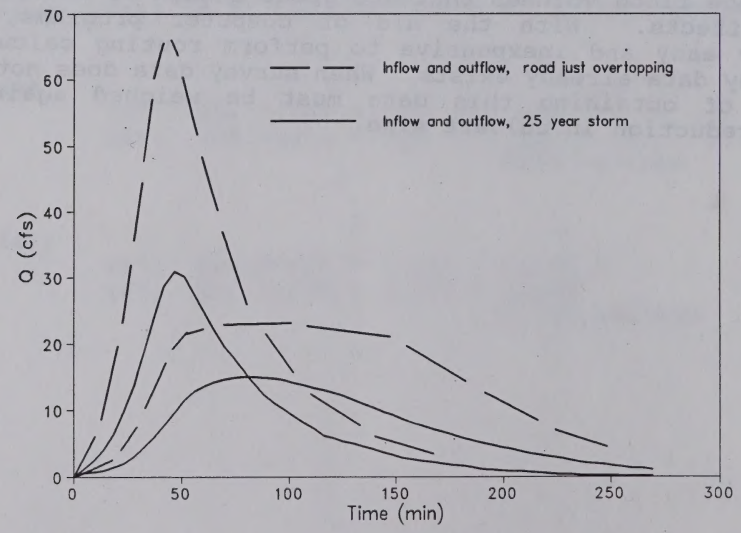


Figure 14; Station 340, 24" culvert



LIMITATIONS:

The regression equations developed in this study may yield estimates with significant error and should be used with caution. One possible reason for this error is that the basin parameters used in this study do not include any measure that indicates basin shape other than the length and slope of the main channel. Basin perimeter, basin slope (proportional to contour length divided by area), and maximum basin relief have been significant variables in other studies (Craig, 1978; Parrett, 1989) but are not included in the published basin parameters.

Besides including a shape factor, another possible way to reduce error in regression equations is to use a nonlinear modeling procedure instead of a log-linear model. The nonlinear results show this technique has potential, even though the results on this data set are not satisfactory. Nonlinear modeling has only recently become practical from a computational standpoint; as knowledge is gained in this field it is likely that it will become a useful tool in hydrological analysis.

When using the methods presented in this paper, it is important to remember that the peak flow values apply to Eastern Montana drainage areas of less than one square mile, and that the hydrograph method was developed for ephemeral streams in a semi-arid climate with drainage areas of less than eleven square miles.

CONCLUSIONS:

The regression analysis shows that one-hour rainfall data is a useful basin parameter for predicting peak flows from small drainage areas. Basin area and average annual precipitation were also found to be significant (equations 8 - 13). As drainage basin area increases, and time of concentration becomes much greater than one hour, the significance of one-hour rainfall data will diminish.

The example problems clearly demonstrate how upstream storage can dramatically affect design and give increased confidence that a culvert will perform satisfactorily, given the inaccuracy of peak flow estimates. For a small drainage area with significant upstream storage, upstream storage will have a much greater effect on culvert selection than variance in the peak flow estimate (figures 13 and 14).

The hydrograph method from the Wyoming study (Craig, 1978) is suggested for use in Eastern Montana. It provides a simple method for developing a storm hydrograph from a peak flow estimate.

REFERENCES CITED

Craig, Gordon S. and James G. Rankl, 1978. Analysis of Runoff from Small Drainage Basins in Wyoming. Geological Survey Water-Supply Paper 2056.

FHWA, 1985. Hydraulic Design of Highway Culverts. Federal Highway Administration, Hydraulic Design Series No. 5. Report No. FHWA-IP-85-15.

Haan, 1977. Statistical Methods in Hydrology. The Iowa State University Press. Ames, Iowa.

Omang, R.J., 1992. Analysis of the Magnitude and Frequency of Floods and the Peak-Flow Gaging Network in Montana. U.S. Geological Survey, Water-Resources Investigations Report 92-4048.

Parrett, Charles and Kenn D. Cartier, 1989. Methods for Estimating Monthly Streamflow Characteristics at Ungaged Sites in Western Montana. U.S. Geological Survey, Open-File Report 89-40.

SCS, 1977. Average Annual Precipitation Montana. Available free from: Soil Conservation Service; Federal Building, Room 443; 10 East Babcock; Bozeman, Montana 59715.

APPENDIX

A. Streamflow Data and Model Output 31

B. Basin Characteristics 32

C. One-hour Rainfall Data 34

A. Streamflow Data and Model Output

Log-linear regression equations

$$Q2 = 2{,}442\ A^{0.6986}\ p^{-1.9916}\ i25^{2.3244}$$
$$Q5 = 17{,}539\ A^{0.6357}\ p^{-2.3436}\ i25^{2.0561}$$
$$Q10 = 51{,}964\ A^{0.6154}\ p^{-2.5528}\ i25^{1.8896}$$
$$Q25 = 112{,}176\ A^{0.5937}\ p^{-2.6276}\ i25^{1.6507}$$
$$Q50 = 148{,}559\ A^{0.5724}\ p^{-2.5958}\ i25^{1.4537}$$
$$Q100 = 198{,}244\ A^{0.5569}\ p^{-2.5800}\ i25^{1.2582}$$
$$Q100^{*} = 419{,}758{,}984\ A^{0.6304}\ elev^{-1.7550}$$

Nonlinear regression equations

$$Q2 = 50.45\ A^{0.73}\ p^{-0.36}\ i25^{2.25}$$
$$Q5 = 4.48\ A^{0.33}\ p^{0.73}\ i25^{3.25}$$
$$Q10 = 7.72\ A^{1.75}\ p^{0.99}\ i25^{2.85}$$
$$Q25 = 4.73\ A^{2.08}\ p^{1.38}\ i25^{3.06}$$
$$Q50 = 5.16\ A^{2.21}\ p^{1.48}\ i25^{3.11}$$
$$Q100 = 1.27(10)^{26}\ A^{4.35}\ elev^{-6.72}$$

* Alternate equation, no calculations performed.

	Actual Data (cfs)						USGS (6 regional equations)						Log-linear Results						Nonlinear Results					
ID	Q2	Q5	Q10	Q25	Q50	Q100	Q2	Q5	Q10	Q25	Q50	Q100	Q2	Q5	Q10	Q25	Q50	Q100	P2	P5	P10	P25	P50	P100
06036600	2	8	17	36	60	97	2	10	24	61	107	180	8	24	45	85	128	185	9	13	18	23	30	2
06062700	2	6	9	15	22	30	3	6	9	17	23	29	4	9	15	26	38	54	9	33	32	47	61	0
06100200	7	29	64	163	310	568	18	60	114	229	342	421	8	25	44	81	120	172	11	17	29	40	52	10
06101520	14	56	109	210	312	438	17	58	112	227	349	441	14	44	77	141	204	285	17	23	62	95	130	88
06101600	8	19	28	43	57	73	6	22	44	92	149	194	7	24	44	84	124	178	7	14	7	7	8	2
06102100	19	64	118	225	338	483	8	33	65	137	229	306	12	36	65	121	178	254	14	18	47	70	96	437
06102300	4	11	21	39	59	86	5	18	36	77	128	169	5	17	31	59	89	129	6	12	6	6	7	2
06109530	4	8	13	26	43	71	8	27	48	85	120	160	6	18	31	56	83	119	12	22	59	97	135	69
06109560	8	25	44	81	121	173	10	35	63	114	164	221	10	28	49	88	130	186	15	21	71	117	165	524
06112800	12	32	51	83	111	144	9	28	48	82	114	150	10	27	45	79	114	158	19	36	125	226	325	59
06124600	22	50	77	122	163	211	7	21	35	59	81	105	10	27	44	75	108	148	19	42	93	156	216	6
06129400	14	36	57	92	123	160	6	19	34	59	83	111	6	17	28	48	70	98	13	34	46	69	92	5
06130800	19	55	97	179	268	388	14	49	92	173	255	353	18	56	99	175	247	336	18	32	39	50	65	47
06130900	11	41	86	185	270	410	17	60	112	210	308	426	22	68	121	212	297	403	23	36	69	99	133	218
06131100	28	75	121	195	261	336	16	58	108	202	295	404	19	57	97	166	229	304	22	52	54	73	94	69
06131300	82	176	249	346	419	492	23	80	148	274	398	543	34	93	155	257	345	448	39	81	166	267	369	744
06137900	12	53	104	199	290	398	9	33	60	106	152	205	20	62	112	201	287	398	21	26	76	115	159	327
06141900	1	8	20	49	84	133	2	10	19	36	53	75	3	11	21	40	61	88	4	11	2	1	1	0
06173300	55	200	367	669	961	1310	26	90	168	308	445	605	43	115	189	306	405	517	49	107	239	402	564	1422
06176950	13	33	51	76	96	116	24	84	157	288	416	560	19	52	84	138	188	245	28	83	100	150	200	334
06177300	9	33	64	128	198	293	12	42	78	148	218	300	12	35	60	103	143	191	16	50	26	30	37	6
06177800	86	330	617	1140	1630	2220	25	87	161	296	429	586	25	64	101	163	218	282	42	110	286	530	764	1414
06177820	24	60	103	175	235	310	18	62	115	216	315	433	18	49	81	135	185	245	27	68	108	169	229	173
06207600	18	43	67	106	141	182	5	21	39	75	118	176	5	19	38	78	124	192	6	4	14	18	24	21
06308100	52	135	230	380	520	700	11	35	62	110	157	210	16	43	70	118	163	218	28	65	150	257	362	61
06308200	8	31	60	122	191	285	8	24	41	73	105	141	6	17	29	50	72	98	8	34	7	6	7	0
06309020	11	29	46	75	101	130	17	60	113	212	311	433	28	78	134	228	313	417	32	54	155	258	363	458
06309060	41	94	140	206	261	319	9	34	64	122	180	248	11	32	57	99	140	190	12	36	13	13	15	1
06326510	12	44	81	148	214	294	25	75	128	222	309	417	21	55	90	152	209	278	31	64	173	303	430	563
06326580	2	5	10	22	37	59	13	40	69	122	173	233	16	44	72	120	166	220	23	66	76	112	148	21
06326650	31	52	66	84	97	110	10	31	53	94	133	180	7	22	38	67	95	130	9	35	8	8	9	0
06326800	37	75	110	166	216	275	17	52	90	158	223	300	34	86	136	216	285	362	50	134	306	551	786	196
06326900	82	159	223	315	393	478	22	76	142	262	380	518	30	85	141	234	316	411	35	78	126	192	259	417
06326950	13	68	142	290	440	624	24	85	158	292	423	577	46	124	202	325	426	541	53	119	267	453	637	1195
06327790	17	29	38	52	63	75	16	48	83	145	204	275	19	51	82	134	181	235	28	92	83	118	154	21
06328400	38	67	88	113	132	149	18	64	119	222	325	447	26	72	117	193	260	338	35	85	140	221	301	226
06328800	14	46	84	156	231	327	22	79	147	271	391	526	24	65	106	173	231	299	30	94	88	124	162	186
06329350	15	35	55	88	118	155	30	88	148	255	353	480	21	59	97	161	218	285	28	77	81	116	151	127
06334610	44	70	87	108	123	137	13	40	70	125	177	237	20	54	89	150	207	276	30	61	171	298	423	127
06334625	3	13	25	48	71	98	11	35	62	110	156	209	13	33	53	89	123	165	23	65	111	182	250	31

B. Description of Basin Characteristics

Q2, Q5,... (cfs): The peak stream flow in cubic feet per second with the return interval given in years. Estimated by the USGS using log-Pearson analysis of stream gage records and historical data.

Yrs USGS: Number of years the stream gage has been in operation.

MaxRec (cfs): The maximum recorded flow at the stream gage.

A (square miles): Area of drainage basin.

p (inches): Average annual precipitation.

i2, i5,... (inches/hr): The maximum rainfall predicted from a storm one hour in duration with the return interval given in years.

Note: All of the basin parameters except for the one-hour storm data are taken from published sources. The one hour-storm data were collected for this project.

Slope (ft/mile): The average slope of the main channel, taken from points 15 and 85 percent along its length.

Length (miles): Main channel length measured from the stream recording gage to the drainage divide.

Elev (ft): The average elevation of the drainage basin above sea level. Determined by averaging the elevations at evenly spaced grid points superimposed on the drainage basin.

I24,2 (inches): The maximum rainfall predicted from a storm 24 hours in duration with a return interval of two years.

Soil Inf (inches): Soil infiltration as determined by the Soil Conservation Service's "S" factor.

Lat Gage (Dec.Deg): Latitude of stream gage in decimal degrees.

Lng Gage (Dec.Deg): Longitude of stream gage in decimal degrees.

Janmin (Fahr): The average minimum January temperature.

E6000 (%): Percentage of basin with elevation greater than 6000 feet.

Stor (%): Percentage of basin covered by lakes and ponds.

Fors (%): Percentage of basin covered by forest.

Basin Characteristics Data

ID	Yrs USGS	MaxRec cfs	Area sqmi	Precip in	I2 in/hr	I5 in/hr	I10 in/hr	I25 in/hr	I50 in/hr	I100 in/hr	Slope ft/mi	Length mi	Elev ft	I24,2 in	SoilInf in	LatGage Dec.Deg	LngGage Dec.Deg	Jan Fahr	E6000 %	Stor %	Fors %
06036600	16	320	0.53	12	0.38	0.57	0.69	0.84	0.95	1.07	247.0	2.20	4540	1.2		45.895	111.609	11	0	0	0
06062700	15	20	0.39	20	0.42	0.67	0.83	1.04	1.19	1.35	1100.0	1.10	6280	1.3		46.588	112.269	10	76.5	0	96.9
06100200	17	249	0.60	13	0.38	0.59	0.72	0.89	1.02	1.15	50.0	1.10	3910	1.5		48.249	112.229	9	0	0	0
06101520	15	92	0.86	12	0.42	0.64	0.79	0.96	1.10	1.23	48.4	1.23	3570	1.4		48.263	111.703	6	0	0.24	0
06101600	16	38	0.26	11	0.42	0.63	0.77	0.94	1.07	1.20	62.0	0.75	2990	1.4		48.231	110.891	6	0	0	0
06102100	15	244	0.84	12	0.41	0.60	0.73	0.89	1.00	1.12	140.0	1.90	2770	1.6	1.8	47.950	110.550	7	0	0	0
06102300	17	42	0.25	12	0.41	0.60	0.73	0.89	1.00	1.12	189.0	1.10	2750	1.6	2.1	47.950	110.500	7	0	0	0
06109530	16	47	0.80	16	0.40	0.59	0.72	0.89	1.02	1.14	195.0	1.17	3530	1.8	1.9	48.086	109.943	6	0	0	0
06109560	15	112	0.96	14	0.40	0.59	0.72	0.89	1.02	1.14	107.0	1.61	2940	1.8	1.8	48.055	110.089	6	0	0.10	0
06112800	15	78	0.99	16	0.47	0.69	0.83	1.02	1.16	1.29	69.3	1.34	4150	1.6	2.2	47.253	109.364	8	0	0.51	0
06124600	15	82	0.74	16	0.50	0.74	0.90	1.10	1.25	1.40	91.5	2.19	4850	1.7	5.6	46.681	109.763	10	0	1.16	0
06129400	15	141	0.51	17	0.46	0.70	0.86	1.06	1.21	1.36	650.0	0.50	3850	1.6	3.7	47.003	108.787	8	0	0	12.1
06130800	16	334	0.52	11	0.48	0.75	0.93	1.15	1.32	1.48	83.3	1.35	2830	1.4	1.2	47.200	106.800	5	0	0	0
06130900	15	458	0.72	11	0.48	0.75	0.93	1.15	1.32	1.48	254.0	0.70	2780	1.4	1.4	47.220	106.830	5	0	0	0
06131100	15	158	0.48	12	0.55	0.86	1.06	1.31	1.50	1.69	86.4	0.94	2540	1.6	2.1	47.386	106.170	5	0	0	0
06131300	15	250	0.79	12	0.58	0.92	1.15	1.43	1.64	1.85	76.6	1.48	2460	1.6	1.8	47.606	106.153	4	0	0	0
06137900	15	299	0.93	11	0.42	0.66	0.81	1.01	1.16	1.31	54.2	2.70	3090	1.5	3.3	48.559	110.421	2	0	1.00	0
06141900	15	72	0.11	12	0.41	0.63	0.77	0.94	1.07	1.20	145.0	0.42	2500	1.6	4.2	48.584	109.430	4	0	0	0
06173300	16	940	0.86	12	0.61	0.98	1.23	1.54	1.78	2.01	65.2	1.85	2360	1.6	1.2	47.893	106.889	2	0	0	0
06176950	16	74	0.53	14	0.62	0.95	1.17	1.45	1.65	1.85	90.9	1.61	2140	1.7	2.8	48.056	105.556	-4	0	0.62	0
06177300	17	234	0.29	13	0.61	0.90	1.09	1.34	1.52	1.70	80.0	1.00	2620	1.5	3.5	47.350	105.680	4	0	0	0
06177800	27	1250	0.91	15	0.63	0.97	1.19	1.47	1.68	1.88	85.7	0.90	2450	1.7	3.2	47.914	105.498	0	0	0	0
06177820	15	105	0.63	14	0.63	0.92	1.10	1.34	1.52	1.69	90.0	1.51	2640	1.5	2.5	47.877	104.935	0	0	0	0
06207600	14	90	0.85	11	0.29	0.41	0.49	0.59	0.67	0.74	310.0	1.72	4380	1.4	1.4	45.162	108.823	12	0	0	0
06308100	17	290	0.80	15	0.56	0.85	1.03	1.27	1.44	1.61	106.0	1.13	3600	1.4	1.2	45.524	105.753	7	0	0.15	0
06308200	33	390	0.14	14	0.56	0.84	1.03	1.26	1.44	1.61	231.0	0.52	2980	1.5	1.9	45.886	105.682	4	0	0	5.0
06309020	17	87	0.96	12	0.51	0.80	1.00	1.24	1.42	1.60	60.9	1.50	3000	1.3	3.0	46.819	106.249	5	0	0	0
06309060	27	320	0.22	12	0.53	0.83	1.02	1.27	1.45	1.64	79.4	0.83	2710	1.3	1.6	46.567	106.064	5	0	0	0
06326510	16	130	0.91	14	0.62	0.88	1.05	1.26	1.43	1.59	74.5	1.88	2810	1.6	2.7	46.431	105.181	4	0	0	11.0
06326580	15	28	0.51	14	0.68	0.95	1.13	1.35	1.52	1.69	122.0	1.15	3160	1.8	2.8	46.194	104.551	4	0	0.37	0
06326650	15	61	0.16	13	0.66	0.90	1.07	1.27	1.44	1.59	198.0	0.63	2780	1.7	1.8	46.419	104.742	4	0	0	0
06326800	27	350	0.86	14	0.83	1.13	1.34	1.60	1.79	1.98	87.4	1.90	3170	1.7	1.9	46.482	104.239	3	0	0.57	0
06326900	15	338	0.67	12	0.62	0.95	1.16	1.44	1.64	1.84	116.0	2.37	2410	1.7	3.9	46.862	105.109	3	0	0	13.0
06326950	27	267	0.87	12	0.64	1.01	1.27	1.59	1.83	2.07	109.0	1.80	2440	1.7	3.3	46.953	104.898	3	0	0	0
06327790	15	16	0.44	14	0.65	1.00	1.23	1.52	1.74	1.95	132.0	0.90	2870	1.6		47.008	104.306	2	0	0.04	0
06328400	16	110	0.67	13	0.68	0.99	1.19	1.45	1.64	1.83	79.2	1.60	2640	1.6	3.3	47.413	104.833	2	0	0	0
06328800	16	150	0.46	13	0.66	1.01	1.25	1.55	1.77	1.99	69.7	1.10	2130	1.6	3.2	47.289	104.527	1	0	0	0
06329350	15	305	0.49	13	0.68	0.98	1.19	1.45	1.64	1.83	104.0	1.21	2350	1.6	2.5	47.509	104.118	0	0	0	5.0
06334610	16	80	0.92	14	0.56	0.83	1.01	1.25	1.41	1.58	74.8	1.96	3530	1.5	1.6	45.387	104.477	4	0	0	0
06334625	15	35	0.64	16	0.62	0.88	1.06	1.28	1.45	1.61	80.8	1.32	3450	1.8	2.5	45.904	104.363	5	0	0.02	5.0

C. One-hour Rainfall Data

The following data set is the maximum recorded one-hour rainfall for each year for these NOAA rain gages.

MT 165	ALZADA
MT 330	ASHLAND RANGER STN
MT 364	AUGUSTA
MT 554	BAYLOR
MT 807	BILLINGS WSO
MT 923	BLOOMFIELD
MT 926	BLOOMFIELD 6 E
MT 1088	BREDETTE
MT 1102	BRIDGER
MT 1127	BROADUS
MT 1202	BROWNING
MT 1737	CHOTEAU
MT 1875	COHAGEN
MT 1880	COHAGEN 9 WSW
MT 1984	CONTENT
MT 1995	COOKE CITY
MT 2054	CORWIN SPRINGS
MT 2158	CUSTER CAA ARPT
MT 2173	CUT BANK FAA AIRPORT
MT 2266	DECKER
MT 2441	DODSON 11 N
MT 2477	DOVETAIL 1 N
MT 2689	EKALAKA
MT 3176	FORT PECK POWER PLNT
MT 3238	FOUR BUTTES
MT 7425	SCOBEY 2
MT 3309	FROID 4 NE
MT 3489	GIBSON DAM
MT 3558	GLASGOW WSO AIRPORT
MT 3581	GLENDIVE
MT 3751	GREAT FALLS WSCMO
MT 3996	HAVRE WSO AIRPORT
MT 4020	HAYS
MT 4055	HELENA WSO
MT 4120	HIGHWOOD
MT 4143	HILGER
MT 4241	HOLTER DAM
MT 4368	ILIAD
MT 4442	ISMAY
MT 4512	JOPLIN 1 N
MT 4663	KINGS HILL
MT 4904	LAVINA
MT 4983	LEWISTOWN 2 SW
MT 4985	LEWISTOWN ARPT
MT 5040	LINCOLN RANGER STN
MT 5086	LIVINGSTON MISS FLD
MT 5106	LODGE GRASS
MT 5122	LOGAN
MT 5387	MARTINSDALE 3 NNW
MT 5685	MILES CITY
MT 5690	MILES CITY FAA ARPT
MT 5706	MILLEGAN
MT 5791	MOLT 6 SW
MT 6001	NEIHART
MT 6008	NEIHART 8 NNW
MT 6946	REEDPOINT
MT 6976	RESERVE 14 W
MT 7028	RIDGE 2 WSW
MT 7258	RUSSELL
MT 7500	SHELBY
MT 7501	SHELBY AIRPORT
MT 7618	SIMMS 1 NE
MT 7858	STANFORD 2 NE
MT 8169	TERRY 25 NW
MT 8329	TOWNSEND 12 ENE
MT 8493	UTICA
MT 8511	VANANDA 5 ESE
MT 8777	WESTBY
MT 8927	WHITE SULPHUR SPRNGS
MT 9052	WINNETT 11 ESE
MT 9103	WOLF POINT
MT 9240	YELLOWTAIL DAM
MT 9900	ZORTMAN
ND 5575	MARMARTH MDU CO
ND 8812	TROTTERS 3 S
ND 9425	WILLISTON WBO
SD 1294	CAMP CROOK
SD 4671	LADNER

Alzada, MT 165

Date		Time	Rain, in.		
08/08	1948	1900	0.60	Max =	1.37
08/18	1949	1800	0.29	Min =	0.20
06/24	1950	2000	1.03	years =	43
06/17	1951	200	0.70		
05/25	1952	1700	0.56		
05/28	1953	2200	1.37	Mean =	0.577
08/05	1954	2200	0.51	s =	0.280
07/23	1955	400	0.48		
06/14	1956	2400	1.12	alpha =	0.218
08/26	1957	2400	1.07	beta =	0.451
06/07	1958	2100	0.75		
06/06	1959	2300	0.55	year	rain
08/17	1960	900	0.44	2	0.53
08/16	1961	600	0.20	5	0.78
07/26	1962	1800	0.48	10	0.94
06/15	1963	1300	0.69	25	1.15
06/17	1964	2100	0.27	50	1.30
06/22	1965	200	0.90	100	1.45
07/28	1966	1200	0.58		
06/06	1967	2400	0.48		
08/22	1968	2000	0.35		
08/31	1969	200	0.55		
08/05	1970	2000	0.31		
06/13	1971	1900	0.79		
05/19	1972	1800	0.36		
06/14	1973	1500	0.46		
07/15	1974	1900	1.15		
06/24	1975	1700	0.57		
07/02	1976	1300	0.65		
09/30	1977	1000	0.36		
05/29	1978	1900	0.44		
07/28	1979	2300	0.39		
09/13	1980	300	0.36		
07/15	1981	200	0.56		
07/24	1982	2100	0.75		
08/21	1983	2200	0.97		
06/18	1984	2000	0.34		
06/24	1985	2000	0.36		
08/31	1986	2400	0.61		
06/19	1987	1900	0.30		
09/28	1988	1200	0.20		
10/29	1989	1300	0.20		
05/23	1990	1900	0.70		

Ashland Ranger Stn, MT 330

Date		Time	Rain, in.		
07/19	1948	2200	0.45	Max =	1.54
07/05	1949	1600	0.78	Min =	0.10
08/10	1950	1800	1.16	years =	42
07/04	1951	1700	0.24		
06/27	1952	600	0.62	Mean =	0.605
06/02	1953	100	1.34	s =	0.330
08/06	1954	1600	0.56		
07/03	1955	2000	0.45	alpha =	0.257
07/15	1956	1700	0.19	beta =	0.457
05/28	1957	1900	0.71		
06/01	1958	2300	0.57	year	rain
07/13	1959	1600	0.50	2	0.55
06/11	1960	1300	0.51	5	0.84
07/06	1961	2000	0.43	10	1.04
06/04	1962	1300	0.28	25	1.28
06/07	1963	2300	0.57	50	1.46
06/16	1964	1700	0.51	100	1.64
06/30	1965	2000	1.54		
07/22	1966	1600	0.44		
06/06	1967	1300	1.02		
05/29	1968	2100	0.85		
10/02	1969	1500	0.18		
10/12	1970	1100	0.10		
06/10	1971	2100	0.35		
06/09	1972	1600	1.32		
06/02	1973	300	0.44		
08/14	1974	2200	0.60		
06/02	1975	1100	0.40		
06/25	1976	800	0.80		
07/05	1977	1700	0.30		
05/22	1978	1900	0.50		
07/25	1979	1400	0.20		
06/14	1980	1600	0.40		
07/23	1981	2000	0.40		
08/20	1982	2200	0.60		
06/16	1983	2000	0.80		
06/18	1984	2000	0.40		
05/27	1985	2200	0.50		
08/31	1986	1600	1.00		
08/15	1987	2000	0.80		
08/12	1988	1600	0.60		
07/09	1990	1600	1.00		

Augusta, MT 364

Date		Time	Rain, in.		
08/19	1949	1600	0.29	Max =	1.80
07/05	1950	1600	0.48	Min =	0.20
07/05	1951	1900	1.80	years =	42
05/03	1952	2300	0.25		
06/28	1953	1800	0.36	Mean =	0.580
08/06	1954	1700	0.23	s =	0.384
07/25	1955	1400	1.19		
07/11	1956	100	1.30	alpha =	0.299
08/06	1957	900	0.33	beta =	0.408
07/29	1958	1900	0.94		
06/16	1959	1800	0.81	year	rain
08/01	1960	1400	0.59	2	0.52
05/30	1961	1600	1.05	5	0.86
05/19	1962	1900	0.34	10	1.08
08/23	1963	2200	0.55	25	1.36
06/07	1964	1400	0.25	50	1.57
06/15	1965	2400	0.75	100	1.78
06/03	1966	1600	0.42		
06/18	1967	1700	1.05		
09/20	1968	300	0.20		
07/05	1969	2200	0.40		
06/14	1970	1300	0.80		
08/29	1971	400	0.20		
08/22	1972	1600	0.60		
04/23	1973	1600	0.20		
08/12	1974	1900	0.50		
04/26	1975	1400	0.50		
08/07	1976	1500	0.30		
09/16	1977	2000	0.30		
07/03	1978	1900	1.00		
06/17	1979	2100	0.40		
05/29	1980	2300	0.30		
05/15	1981	1700	1.40		
06/28	1982	1900	0.40		
06/18	1983	300	0.30		
06/12	1984	1100	1.00		
08/10	1985	2100	0.30		
06/29	1986	100	0.90		
06/16	1987	1000	0.30		
09/18	1988	300	0.20		
06/15	1989	1700	0.40		
05/24	1990	2000	0.50		

Baylor, MT 554

Date		Time	Rain, in.		
07/07	1948	2000	1.40	Max =	2.01
06/24	1949	1900	0.29	Min =	0.14
08/10	1950	2300	0.41	years =	43
03/05	1951	200	0.34		
07/19	1952	2100	0.50	Mean =	0.629
06/30	1953	900	0.31	s =	0.411
08/26	1954	1700	0.90		
06/03	1955	900	0.42	alpha =	0.321
06/18	1956	900	0.19	beta =	0.444
07/14	1957	1300	0.33		
06/01	1958	700	0.21	year	rain
06/20	1959	1900	0.71	2	0.56
05/18	1960	2000	0.30	5	0.92
08/01	1961	2000	0.45	10	1.17
06/13	1962	100	0.36	25	1.47
07/10	1963	1700	0.98	50	1.70
07/18	1964	1700	1.16	100	1.92
08/05	1965	1300	0.83		
05/31	1966	1900	0.81		
07/14	1967	2200	0.94		
06/23	1968	1400	0.78		
07/15	1969	400	0.28		
06/14	1970	1500	1.07		
06/23	1971	1900	0.49		
08/13	1972	2200	1.79		
07/23	1973	1800	0.61		
07/07	1974	2100	0.91		
08/07	1975	1700	0.57		
06/05	1976	1400	0.86		
05/17	1977	1700	0.60		
07/29	1978	1400	0.46		
07/04	1979	2000	0.14		
06/12	1980	2300	0.40		
07/13	1981	1900	0.37		
06/15	1982	2200	0.40		
07/10	1983	300	2.01		
06/04	1984	1900	0.38		
08/02	1985	2200	0.30		
06/25	1986	2200	0.49		
07/18	1987	600	0.30		
08/18	1988	2000	1.10		
08/24	1989	2200	0.50		
05/30	1990	2100	0.40		

Billings WSO, MT 807

Date	Time	Rain, in.
07/14 1948	2400	0.24
07/05 1949	2000	0.61
06/12 1950	1900	0.59
08/14 1951	400	0.25
09/10 1952	2000	0.78
05/27 1953	2400	0.44
09/12 1954	2400	0.36
07/06 1955	1500	0.89
07/06 1956	1400	0.54
06/06 1957	1800	0.51
07/02 1958	1800	1.86
04/26 1959	2000	0.26
08/14 1960	2100	0.35
04/23 1961	100	0.39
05/20 1962	1800	0.48
06/04 1963	1900	0.40
06/08 1964	1600	0.53
07/12 1965	1400	0.56
07/25 1966	2000	0.92
06/06 1967	1800	0.71
09/12 1968	1400	0.49
07/18 1969	1300	0.69
05/27 1970	1700	0.33
05/04 1971	1600	0.26
08/02 1972	2000	0.47
08/22 1973	1900	0.42
07/02 1974	2100	0.35
07/04 1975	200	0.79
05/14 1976	1700	0.32
07/19 1977	2400	0.35
07/10 1978	1600	0.54
03/17 1979	400	0.30
06/11 1980	1800	0.38
07/13 1981	1600	0.94
06/16 1982	1800	0.85
07/27 1983	1800	0.55
08/04 1984	1700	0.36
08/01 1985	1600	0.38
06/26 1986	2000	0.54
07/21 1987	1800	0.41
05/07 1988	100	0.23
08/24 1989	1700	0.42
08/17 1990	2200	0.61

Max =	1.86
Min =	0.23
years =	43
Mean =	0.527
s =	0.283
alpha =	0.220
beta =	0.400

year	rain
2	0.48
5	0.73
10	0.90
25	1.10
50	1.26
100	1.41

Bloomfield, MT 923

Date	Time	Rain, in.
07/02 1969	100	1.31
08/06 1970	1400	0.98
06/13 1971	2100	0.49
07/27 1972	2100	0.69
04/18 1973	300	0.22
07/16 1975	2400	0.39
07/01 1976	2300	1.56
06/14 1977	2000	0.29
06/14 1978	2000	0.76
07/29 1979	1600	0.47
06/12 1980	2300	0.26

Bloomfield 6 E, MT 926

08/06 1948	2000	1.50
07/27 1949	2200	0.25
08/12 1950	2200	0.85
09/01 1951	1500	0.97
07/19 1952	1700	0.72
06/29 1953	100	0.73
08/26 1954	1800	0.55
07/04 1955	1100	0.58
06/18 1956	500	0.43
07/14 1957	2200	0.96
07/10 1958	1200	0.75
06/26 1959	1800	1.19
06/20 1960	1600	0.55
05/30 1961	1400	0.50
07/13 1962	2300	0.84
06/21 1963	1800	0.79
07/05 1964	200	1.00
06/30 1965	2100	0.90
07/02 1966	1500	0.97
06/11 1967	1400	0.80
06/23 1968	1300	0.30

Max =	1.56
Min =	0.22
years =	32
Mean =	0.736
s =	0.348
alpha =	0.271
beta =	0.579

year	rain
2	0.68
5	0.99
10	1.19
25	1.45
50	1.64
100	1.83

Bredette, MT 1088

Date		Time	Rain, in.		
06/03	1940	1700	0.76	Max =	1.50
07/27	1941	1900	0.55	Min =	0.12
08/26	1942	2300	1.28	years =	51
08/31	1943	100	1.12		
08/09	1944	200	0.90	Mean =	0.643
06/22	1945	2200	0.29	s =	0.325
07/09	1946	1300	1.50		
08/12	1947	2300	1.30	alpha =	0.253
07/07	1948	2100	0.42	beta =	0.497
05/30	1949	300	0.32		
07/10	1950	2000	0.29	year	rain
09/02	1951	1700	1.14	2	0.59
06/27	1952	2100	0.30	5	0.88
07/15	1953	2100	0.75	10	1.07
09/03	1954	2000	0.35	25	1.31
07/06	1955	2000	0.63	50	1.49
08/07	1956	100	0.27	100	1.66
07/14	1957	1600	0.62		
08/30	1958	200	0.21		
06/23	1959	100	0.49		
08/25	1960	200	0.93		
06/30	1961	100	0.42		
07/01	1962	2200	0.44		
06/28	1963	2300	0.78		
06/14	1964	1800	0.45		
06/30	1965	2000	0.77		
07/02	1966	1400	0.57		
06/18	1967	1100	0.83		
06/23	1968	1300	1.30		
07/19	1969	1500	1.00		
06/14	1970	1800	0.58		
06/23	1971	2000	0.93		
05/25	1972	2200	0.78		
08/04	1973	1600	0.56		
07/07	1974	600	0.40		
06/27	1975	1900	0.64		
08/04	1976	1300	1.00		
06/12	1977	900	0.29		
07/03	1978	2300	0.92		
07/30	1979	1000	0.54		
07/13	1980	1900	0.34		
05/31	1981	2400	0.52		
06/27	1982	2000	0.42		
07/10	1983	400	0.83		
06/11	1984	1100	0.12		
08/02	1985	2200	0.40		
07/04	1986	1800	0.26		
08/14	1987	1600	0.30		
06/29	1988	1300	0.60		
06/27	1989	2100	0.60		
07/25	1990	1300	0.80		

Bridger, MT 1102

Date		Time	Rain, in.		
07/14	1948	500	0.44	Max =	0.87
07/05	1949	1900	0.21	Min =	0.17
08/12	1950	1800	0.87	years =	43
06/07	1951	400	0.20		
06/27	1952	1400	0.50	Mean =	0.315
06/15	1953	500	0.32	s =	0.136
08/05	1954	1500	0.21		
05/26	1955	1800	0.25	alpha =	0.106
06/21	1956	100	0.21	beta =	0.254
09/01	1957	1300	0.33		
06/18	1958	1700	0.35	year	rain
08/20	1959	800	0.21	2	0.29
08/16	1960	800	0.40	5	0.41
09/20	1961	1900	0.19	10	0.49
06/15	1962	2200	0.23	25	0.59
09/02	1963	1800	0.75	50	0.67
06/08	1964	2200	0.39	100	0.74
04/25	1965	1700	0.35		
06/23	1966	1600	0.39		
06/08	1967	1700	0.27		
06/09	1968	700	0.27		
06/10	1969	800	0.28		
03/29	1970	1300	0.28		
02/04	1971	2000	0.20		
08/23	1972	1100	0.22		
09/14	1973	1000	0.23		
06/08	1974	400	0.31		
07/31	1975	200	0.30		
08/02	1976	1600	0.30		
05/19	1977	2000	0.17		
09/07	1978	2200	0.34		
10/15	1979	2200	0.32		
05/24	1980	2200	0.25		
10/08	1981	800	0.18		
06/22	1982	1600	0.34		
07/09	1983	2300	0.17		
04/27	1984	1000	0.43		
08/02	1985	1300	0.40		
07/11	1986	1200	0.30		
05/27	1987	800	0.30		
05/07	1988	700	0.30		
10/28	1989	1300	0.30		
05/29	1990	1000	0.30		

Broadus, MT 1127

Date	Time	Rain, in.
06/24 1942	2200	0.41
08/31 1943	700	1.00
06/22 1944	900	0.85
08/02 1945	1800	0.55
07/05 1946	2100	1.00
06/29 1947	1400	0.64
06/03 1948	100	0.93
08/18 1949	1500	0.50
09/20 1950	1200	0.37
06/09 1951	1900	0.42
05/29 1952	1700	0.43
08/10 1953	300	1.42
09/04 1954	2000	0.90
06/27 1955	1900	0.65
08/27 1956	1800	0.29
04/22 1957	1500	1.07
06/07 1958	2000	0.78
06/25 1959	1900	1.20
06/15 1960	1100	0.43
07/28 1961	1900	0.45
07/13 1962	2000	0.76
07/22 1963	2000	0.46
06/15 1964	2400	0.60
07/12 1965	1700	0.37
09/02 1966	1600	0.93
06/18 1967	1400	0.39
05/29 1968	2000	0.48
07/16 1969	1800	0.18
05/21 1970	300	0.39
10/02 1971	200	0.37
06/09 1972	600	1.71
08/10 1973	1700	0.60
07/03 1974	300	0.50
06/18 1975	1400	0.30
05/25 1976	1300	0.50
06/15 1977	1700	0.70
08/27 1978	1200	0.40
06/27 1979	1400	0.40
06/19 1980	1500	1.10
06/13 1981	100	0.50
06/07 1982	2000	0.60
08/21 1983	2000	0.20
07/28 1984	2200	0.70
05/28 1985	1600	0.50
09/24 1986	2100	0.50
07/17 1987	2100	0.70
08/12 1988	1600	0.60
04/28 1989	800	0.40
06/16 1990	1700	0.30

Max =	1.71
Min =	0.18
years =	49
Mean =	0.621
s =	0.314
alpha =	0.244
beta =	0.480

year	rain
2	0.57
5	0.85
10	1.03
25	1.26
50	1.43
100	1.60

Browning, MT 1202

Date	Time	Rain, in.
09/04 1949	1000	0.38
09/02 1951	200	0.40
06/21 1952	1200	0.30
08/04 1953	400	0.49
08/15 1954	1600	0.45
07/25 1955	600	0.25
06/14 1956	2300	0.27
06/06 1957	300	0.23
07/29 1958	1600	0.54
09/16 1959	1100	0.24
07/03 1960	2100	0.21
07/22 1961	1500	0.70
06/25 1962	1400	0.56
06/29 1963	500	0.44
06/08 1964	1300	0.56
07/08 1965	1400	0.60
07/01 1966	2200	0.28
10/28 1967	400	0.23
06/05 1968	1100	0.36
06/06 1969	2200	0.33
08/02 1970	1200	0.68
06/29 1971	800	0.40
06/09 1972	200	0.25
04/24 1973	1800	0.15
07/10 1974	1600	0.15
07/31 1975	2300	0.30
08/05 1976	1700	0.67
06/16 1977	1900	0.44
07/03 1978	1500	0.83
06/18 1979	100	0.19
06/10 1980	2000	0.60
05/25 1981	1800	0.30
06/29 1982	2200	0.70
06/29 1983	2000	0.40
06/13 1984	1800	0.20
05/29 1985	1700	0.70
09/30 1986	2300	0.20
07/22 1987	500	0.30
07/05 1988	1600	0.30
06/09 1989	1800	0.40
05/28 1990	2400	0.50

Max =	0.83
Min =	0.15
years =	41
Mean =	0.402
s =	0.179
alpha =	0.140
beta =	0.321

year	rain
2	0.37
5	0.53
10	0.64
25	0.77
50	0.87
100	0.96

Choteau, MT 1737

Date	Time	Rain, in.
09/22 1940	1300	0.44
06/04 1941	1400	0.48
05/24 1942	1800	1.20
05/14 1943	1700	0.29
07/04 1944	1900	0.73
06/02 1945	1500	0.34
06/23 1946	1700	0.30
08/22 1947	1500	0.76
08/01 1948	2100	0.91
07/05 1949	1600	1.14
06/14 1950	1900	0.64
08/12 1951	1400	0.83
05/14 1952	2000	0.63
06/07 1953	2100	0.86
08/26 1954	1500	0.43
07/25 1955	1400	0.77
08/02 1956	1900	0.74
06/21 1957	1500	0.31
05/31 1958	2100	0.39
06/16 1959	1900	0.55
08/07 1960	500	0.15
05/29 1961	1800	0.20
07/01 1962	1500	0.36
06/28 1963	1600	0.45
07/02 1964	1700	0.47
07/21 1965	1500	0.58
08/26 1966	1700	0.11
06/06 1967	1100	0.42
05/24 1968	1300	0.15
07/05 1969	1800	0.30
07/13 1970	800	0.27
09/23 1971	1700	0.10
06/09 1972	1800	0.60
07/21 1973	1700	0.40
08/13 1974	400	0.20
05/09 1975	2100	0.40
06/04 1976	2000	0.40
03/30 1977	1000	0.40
06/30 1978	1500	0.80
06/17 1979	2100	0.40
06/12 1980	1800	0.50
07/13 1981	2000	0.50
07/13 1982	1100	0.40
06/18 1983	300	0.30
06/21 1984	1100	0.30
09/17 1985	2200	0.40
06/28 1986	2400	0.40
06/18 1987	1800	0.60
06/28 1988	1800	0.40
06/17 1989	2100	0.30
08/19 1990	2200	0.30

Max =	1.20
Min =	0.10
years =	51
Mean =	0.476
s =	0.243
alpha =	0.190
beta =	0.367

year	rain
2	0.44
5	0.65
10	0.79
25	0.97
50	1.11
100	1.24

Cohagen, MT 1875

Date	Time	Rain, in.
07/01 1948	2000	0.26
05/30 1949	1600	0.45
06/12 1950	2200	0.25
08/12 1951	1900	0.45
09/13 1967	1400	0.61
07/15 1968	2300	0.29
07/06 1969	2200	0.70
07/27 1970	1800	0.55
06/25 1971	200	0.50
08/13 1972	2400	1.42
08/22 1973	2300	0.45
10/31 1974	400	0.28
05/05 1975	2100	0.30
07/04 1976	1900	0.61
09/06 1977	700	0.31
06/13 1978	1800	0.52
05/06 1979	400	0.23
07/17 1980	1500	0.49
10/12 1981	200	0.20
10/01 1982	400	0.10
07/10 1983	200	0.70
06/11 1984	600	0.30
02/18 1985	600	1.00
09/24 1986	2400	0.50
07/29 1987	1900	0.70
09/18 1988	500	0.70
08/30 1989	2100	0.60
06/27 1990	2100	1.10

Max =	1.42
Min =	0.10
years =	43
Mean =	0.521
s =	0.304
alpha =	0.237
beta =	0.384

year	rain
2	0.47
5	0.74
10	0.92
25	1.14
50	1.31
100	1.47

Cohagen 9 WSW, MT 1880

Date	Time	Rain, in.
06/27 1952	700	0.21
06/23 1953	2000	1.35
05/25 1954	1700	0.29
08/22 1955	2200	0.52
07/06 1956	800	0.39
08/27 1957	2300	0.34
07/03 1958	1400	1.11
06/26 1959	1400	0.40
07/12 1960	1600	0.24
09/09 1961	2100	0.55
05/13 1962	700	0.26
06/04 1963	2300	0.50
06/10 1964	1700	0.37
07/11 1965	1900	0.39
06/30 1966	2300	0.90

Content, MT 1984

Date	Time	Rain, in.		
07/13 1948	800	0.35	Max =	1.83
07/06 1949	1900	0.30	Min =	0.16
06/12 1950	100	0.42	years =	43
06/05 1951	2000	0.35		
07/19 1952	2000	0.72		
06/12 1953	2400	0.61	Mean =	0.611
08/16 1954	1800	0.30	s =	0.392
07/25 1955	2000	0.55		
05/27 1956	1900	0.55	alpha =	0.305
09/04 1957	1200	1.83	beta =	0.435
07/03 1958	1500	0.40		
06/17 1959	100	0.55	year	rain
08/01 1960	1800	0.95	2	0.55
05/21 1961	1000	0.40	5	0.89
06/14 1962	100	0.90	10	1.12
07/09 1963	2300	0.95	25	1.41
05/03 1964	200	0.39	50	1.63
06/14 1965	2200	1.39	100	1.84
07/03 1966	100	0.50		
06/02 1967	1900	0.40		
06/19 1968	2100	0.78		
07/06 1969	2200	0.25		
07/28 1970	1400	0.90		
06/04 1971	1600	0.26		
08/13 1972	2000	1.76		
06/14 1973	1900	0.59		
08/19 1974	2300	0.90		
08/07 1975	1400	1.31		
06/08 1976	200	0.41		
09/17 1977	1500	0.19		
07/03 1978	2300	0.64		
06/27 1979	1600	0.16		
05/24 1980	1800	0.24		
07/13 1981	1800	0.80		
07/31 1982	2300	0.32		
07/19 1983	1700	0.89		
06/05 1984	1500	0.28		
08/02 1985	2100	0.41		
09/25 1986	500	0.69		
06/16 1987	2000	0.2		
07/04 1988	300	0.7		
06/10 1989	1400	0.3		
08/24 1990	2100	0.50		

Cooke City, MT 1995

Date	Time	Rain, in.		
12/27 1967	2100	0.15	Max =	0.80
07/04 1968	1600	0.37	Min =	0.15
07/14 1969	1400	0.32	years =	23
07/08 1970	1500	0.30		
07/22 1971	1400	0.36	Mean =	0.325
09/10 1972	900	0.25	s =	0.134
08/10 1973	1300	0.24		
08/03 1974	1600	0.33	alpha =	0.105
07/17 1975	1500	0.25	beta =	0.264
10/02 1976	800	0.30		
12/07 1977	1900	0.50	year	rain
09/18 1978	600	0.20	2	0.30
06/18 1979	1500	0.20	5	0.42
11/07 1980	2300	0.30	10	0.50
07/26 1981	1500	0.40	25	0.60
08/19 1983	2300	0.30	50	0.67
09/05 1984	1900	0.30	100	0.75
07/30 1985	2400	0.30		
08/26 1986	1600	0.30		
08/23 1987	1800	0.30		
05/07 1988	1600	0.80		
03/01 1989	900	0.50		
04/02 1990	1700	0.20		

Corwin Springs, MT 2054

Date		Time	Rain, in.
08/04	1951	300	0.38
08/02	1952	1500	0.40
07/08	1953	1500	0.18
07/27	1954	1300	0.35
08/13	1955	1800	0.49
12/13	1956	1000	0.16
06/02	1957	2000	0.28
05/07	1958	1600	0.14
07/13	1959	1400	0.24
08/23	1960	300	0.19
07/31	1961	1500	0.42
09/21	1962	1600	0.39
05/25	1963	2000	0.28
07/29	1964	2100	0.45
05/22	1965	1700	0.26
09/14	1966	1900	0.31
10/05	1967	1700	0.38
08/02	1968	1500	0.40
08/12	1969	700	0.32
07/27	1970	1500	0.28

Max =	0.49
Min =	0.14
years =	20
Mean =	0.315
s =	0.100
alpha =	0.078
beta =	0.270

year	rain
2	0.30
5	0.39
10	0.45
25	0.52
50	0.57
100	0.63

Custer CAA Arpt, MT 2158

Date		Time	Rain, in.
07/10	1948	2200	0.98
06/26	1949	2200	0.28
06/24	1950	600	0.10
08/31	1951	300	0.49
06/25	1952	700	0.23
05/29	1953	900	0.30
06/26	1954	2100	0.25
06/26	1955	2100	0.23
09/12	1956	1700	0.51
08/12	1957	1800	1.00
05/23	1958	1300	0.40
04/15	1959	2200	0.44
08/05	1960	2100	0.40
09/10	1961	300	0.35
07/13	1962	1700	1.41
06/04	1963	2100	1.00
06/17	1964	2100	0.50
07/09	1965	2300	0.52
06/03	1966	1700	0.27
06/10	1967	1800	0.35
05/05	1968	1500	0.39
06/06	1969	1900	1.28
05/07	1970	2000	0.20
06/10	1971	1800	0.61
07/18	1972	2100	0.42
08/22	1973	800	0.30
08/20	1974	1300	0.33
05/16	1975	1900	0.30

Max =	1.41
Min =	0.10
years =	28
Mean =	0.494
s =	0.332
alpha =	0.259
beta =	0.345

year	rain
2	0.44
5	0.73
10	0.93
25	1.17
50	1.35
100	1.53

Cut Bank FAA Airport, MT 2173

Date	Time	Rain, in.		
07/23 1948	1900	0.24	Max =	1.30
07/27 1949	1300	0.44	Min =	0.16
08/11 1950	2000	0.31	years =	43
08/30 1951	200	0.45		
06/27 1952	1300	0.28	Mean =	0.339
06/07 1953	2300	0.30	s =	0.200
08/26 1954	1600	0.38		
07/25 1955	1400	0.40	alpha =	0.156
07/11 1956	1500	1.30	beta =	0.249
08/10 1957	1900	0.48		
08/22 1958	100	0.30	year	rain
06/21 1959	1400	0.25	2	0.31
08/01 1960	2400	0.29	5	0.48
06/18 1961	2400	0.33	10	0.60
08/04 1962	800	0.38	25	0.75
06/05 1963	1500	0.19	50	0.86
07/02 1964	1800	0.19	100	0.97
08/24 1965	500	0.38		
07/02 1966	1700	0.34		
06/09 1967	2400	0.16		
08/20 1968	1700	0.19		
06/24 1969	1400	0.19		
06/12 1970	1900	0.38		
05/20 1971	700	0.31		
05/10 1972	1700	0.23		
05/25 1973	500	0.20		
07/10 1974	2100	0.16		
06/23 1975	1500	0.31		
08/04 1976	1300	0.29		
08/21 1977	2100	0.30		
09/06 1978	2300	0.50		
06/17 1979	2400	0.26		
08/18 1980	1900	0.24		
08/20 1981	1800	0.20		
07/01 1982	1700	0.18		
08/12 1983	600	0.25		
06/21 1984	1200	0.24		
08/22 1985	500	0.63		
06/04 1986	1500	0.86		
06/18 1987	1900	0.35		
05/06 1988	2300	0.20		
06/21 1989	800	0.40		
07/25 1990	500	0.30		

Decker, MT 2266

Date	Time	Rain, in.		
07/18 1949	1300	0.25	Max =	1.29
08/11 1950	1900	0.77	Min =	0.17
08/14 1951	1000	0.60	years =	10
06/07 1952	1800	0.54		
05/29 1953	700	0.96	Mean =	0.641
07/15 1954	1700	1.29	s =	0.323
05/22 1955	800	0.17		
07/02 1956	1900	0.52	alpha =	0.252
08/29 1957	1900	0.65	beta =	0.495
07/02 1958	2300	0.66		
			year	rain
			2	0.59
			5	0.87
			10	1.06
			25	1.30
			50	1.48
			100	1.66

Dodson 11 N, MT 2441

Date	Time	Rain, in.
09/05 1952	1700	0.17
06/02 1953	1600	0.59
08/04 1954	1900	1.02
07/25 1955	1900	0.42
06/20 1956	2200	0.80
09/01 1957	1200	0.30
06/12 1958	1800	0.37
06/27 1959	100	0.31
06/25 1960	1700	0.25
07/30 1961	1300	0.82
07/13 1962	2100	0.96
07/05 1963	1600	1.09
07/15 1964	1700	0.80
06/30 1965	1600	0.97
06/22 1966	300	0.43
07/05 1967	2300	0.34
05/06 1968	200	0.26
07/06 1969	2100	0.30
06/29 1970	2000	0.52
04/17 1971	1800	0.08
06/03 1972	2100	0.27
09/20 1973	1700	0.15
08/08 1974	1400	0.47
07/05 1975	2000	1.17
07/11 1976	2200	0.45
07/09 1977	1800	0.36
09/08 1978	2400	0.75
07/03 1979	1300	0.62
06/23 1980	1100	0.37
07/29 1981	2100	0.41
08/11 1982	2200	0.30
07/10 1983	400	0.56
06/05 1984	1500	0.32
08/02 1985	2200	0.66
05/04 1986	2100	0.43
06/10 1987	200	0.34
06/29 1988	1700	0.30
08/25 1989	600	0.70
07/25 1990	1700	0.60

Max =	1.17
Min =	0.08
years =	39
Mean =	0.514
s =	0.275
alpha =	0.215
beta =	0.390

year	rain
2	0.47
5	0.71
10	0.87
25	1.08
50	1.23
100	1.38

Dovetail 1 N, MT 2477

Date	Time	Rain, in.
06/21 1940	2300	0.50
06/28 1941	100	0.73
06/26 1942	900	0.69
06/13 1943	2000	1.38
06/16 1944	2100	0.98
07/04 1945	1200	0.30
06/06 1946	300	0.41
07/03 1947	2400	0.43
07/13 1948	2000	0.65
08/19 1949	1700	0.26
07/01 1950	1300	0.29
08/13 1951	1100	0.79
07/19 1952	500	0.32
06/09 1953	2400	0.32
08/16 1954	1800	1.20
07/25 1955	1800	0.27
08/26 1956	900	0.27
06/08 1957	2300	0.26
07/03 1958	1100	0.49
06/06 1959	1800	0.40
04/24 1960	500	0.27
07/28 1961	2000	0.31
06/12 1962	2200	0.66
06/06 1963	200	0.23
05/04 1964	300	0.23
06/17 1965	200	0.17
06/20 1966	2400	0.22
07/04 1967	500	0.12
10/26 1968	800	0.11
05/31 1969	1500	0.21
07/11 1970	1800	0.26
06/08 1971	1700	0.66
05/20 1972	2200	0.33
07/22 1973	1500	0.16
07/07 1974	1900	0.44

Max =	1.38
Min =	0.11
years =	35
Mean =	0.438
s =	0.297
alpha =	0.232
beta =	0.304

year	rain
2	0.39
5	0.65
10	0.83
25	1.05
50	1.21
100	1.37

Ekalaka, MT 2689

Date	Time	Rain, in.		
08/15 1949	1700	0.61	Max =	1.31
06/24 1950	2200	1.01	Min =	0.23
09/03 1951	100	0.75	years =	42
05/30 1952	1900	0.23		
06/14 1953	2300	1.15	Mean =	0.636
09/05 1954	1800	0.82	s =	0.286
07/22 1955	1300	1.07		
05/28 1956	100	0.41	alpha =	0.223
07/01 1957	2000	0.52	beta =	0.507
06/04 1958	300	0.55		
06/25 1959	2100	1.31	year	rain
08/06 1960	1000	0.96	2	0.59
07/05 1961	1500	0.40	5	0.84
07/26 1962	1600	0.69	10	1.01
06/05 1963	700	0.86	25	1.22
08/21 1964	1200	0.27	50	1.38
07/04 1965	2300	0.52	100	1.53
05/13 1966	1800	0.60		
06/11 1967	1800	1.25		
07/17 1968	1300	0.67		
07/20 1969	700	0.41		
05/27 1970	2300	0.32		
10/02 1971	400	0.30		
06/09 1972	2100	0.31		
09/01 1973	1000	0.50		
10/30 1974	2400	0.32		
05/31 1975	1600	0.62		
06/06 1976	2300	0.37		
09/30 1977	1100	0.36		
07/18 1978	2000	0.47		
09/10 1979	200	0.92		
06/04 1980	2300	0.75		
06/13 1981	300	0.65		
12/24 1982	1100	0.35		
07/19 1983	2100	0.56		
08/02 1984	1100	1.06		
08/02 1985	1800	0.49		
09/01 1986	300	0.60		
07/27 1987	600	0.80		
06/29 1988	1400	0.50		
07/13 1989	1700	1.00		
08/11 1990	2000	0.40		

Fort Peck Power Plant, MT 3176

Date	Time	Rain, in.		
07/19 1957	700	0.43	Max =	2.30
04/03 1958	1800	0.38	Min =	0.20
06/17 1959	400	0.49	years =	34
08/25 1960	300	0.59		
06/13 1961	500	0.37	Mean =	0.702
06/14 1962	300	0.41	s =	0.458
06/05 1963	2100	0.70		
06/17 1964	2300	0.73	alpha =	0.357
07/07 1965	2000	1.29	beta =	0.496
08/20 1966	800	0.60		
09/11 1967	2000	0.49	year	rain
08/18 1968	800	0.75	2	0.63
07/14 1969	300	0.55	5	1.03
04/28 1970	1800	0.30	10	1.30
06/03 1971	1900	0.60	25	1.64
08/20 1972	1900	0.90	50	1.89
06/30 1973	2100	0.40	100	2.14
06/20 1974	2400	1.70		
07/30 1975	2200	0.70		
08/08 1976	2100	1.50		
06/12 1977	600	0.60		
07/31 1978	2200	0.60		
07/04 1979	1400	0.30		
07/19 1980	1900	0.40		
07/13 1981	2000	2.30		
08/26 1982	900	0.20		
07/17 1983	2400	1.40		
06/20 1984	2000	0.40		
07/24 1985	1700	1.00		
06/29 1986	600	0.60		
07/29 1987	400	1.00		
06/26 1988	2100	0.40		
08/24 1989	2300	0.40		
08/25 1990	100	0.40		

Four Buttes, MT 3238

Date		Time	Rain, in.		
08/15	1949	1800	0.27	Max =	1.10
04/22	1950	2200	0.14	Min =	0.10
04/29	1951	1800	0.68	years =	37
07/19	1952	2200	0.24		
06/30	1953	1300	0.68	Mean =	0.475
09/13	1954	400	0.32	s =	0.238
09/20	1955	300	0.42		
08/28	1956	1000	0.58	alpha =	0.185
04/23	1957	1900	0.79	beta =	0.368
07/08	1958	1900	0.20		
06/26	1959	1800	0.87	year	rain
08/25	1960	1000	0.26	2	0.44
05/30	1961	1600	0.40	5	0.65
07/18	1962	1900	0.64	10	0.79
06/03	1963	1000	0.48	25	0.96
07/04	1964	400	0.29	50	1.09
06/30	1965	1900	0.42	100	1.22
07/13	1966	500	0.53		
06/17	1967	1900	0.92		
08/15	1968	800	0.13		
07/23	1969	1500	0.32		
06/13	1970	100	0.30		
06/03	1971	2200	0.65		
07/25	1972	200	0.74		
08/13	1974	2400	0.51		

Scobey 2, MT 7425

08/08	1979	2000	0.50		
07/19	1980	1800	0.60		
10/12	1981	900	0.20		
05/09	1982	1900	0.10		
08/22	1983	1100	0.50		
06/07	1984	1800	0.20		
07/24	1985	1800	0.50		
07/10	1986	1500	0.60		
07/10	1987	200	0.40		
06/29	1988	1300	1.10		
06/27	1989	2200	0.70		
07/26	1990	1500	0.40		

Froid 4 NE, MT 3309

Date		Time	Rain, in.		
08/09	1948	1400	0.33	Max =	1.30
05/17	1949	400	0.29	Min =	0.27
08/05	1950	2300	0.55	years =	42
09/02	1951	1900	0.32		
06/26	1953	1700	0.87	Mean =	0.614
07/21	1954	1700	1.26	s =	0.267
06/16	1955	800	0.41		
07/14	1956	1800	0.52	alpha =	0.208
05/07	1957	1900	0.79	beta =	0.494
07/15	1958	1200	0.30		
06/09	1959	2400	0.92	year	rain
08/25	1960	400	0.52	2	0.57
06/30	1961	200	0.69	5	0.81
06/06	1962	1400	0.44	10	0.96
08/26	1963	300	1.30	25	1.16
07/10	1964	1600	0.85	50	1.31
06/15	1965	100	0.44	100	1.45
06/30	1966	2400	0.80		
07/06	1967	2400	0.43		
08/23	1968	700	0.30		
06/06	1969	1300	0.88		
08/06	1970	1500	0.82		
07/11	1971	500	0.61		
06/25	1972	900	0.41		
09/01	1973	1500	0.27		
07/07	1974	700	0.60		
08/07	1975	600	0.30		
06/08	1976	300	1.08		
07/13	1977	1400	0.28		
07/04	1978	100	1.05		
06/22	1979	1700	0.48		
06/27	1980	200	0.64		
07/19	1981	1400	0.36		
05/28	1982	1400	0.67		
07/18	1983	200	0.89		
08/06	1984	2100	0.68		
08/02	1985	2200	0.68		
07/04	1986	2200	0.67		
07/29	1987	2300	0.50		
05/06	1988	2300	0.40		
07/17	1989	1600	0.60		
08/26	1990	900	0.60		

Gibson Dam, MT 3489

Date	Time	Rain, in.
07/19 1948	1000	0.32
08/23 1949	1400	0.30
06/11 1950	1900	0.78
04/30 1951	1200	0.25
08/08 1952	300	0.25
07/13 1953	2100	0.56
07/21 1954	200	0.16
07/17 1955	1800	0.39
07/03 1956	300	0.30
05/19 1957	1800	0.35
07/20 1958	1300	0.40
09/14 1959	1800	0.30
08/01 1960	1700	0.24
06/11 1961	1900	0.15
05/24 1962	1700	0.28
08/24 1963	1700	0.30
06/08 1964	500	0.61
06/15 1965	2400	0.41
07/01 1966	1900	0.67
05/30 1967	2200	0.31
12/04 1968	500	0.40
04/10 1969	1800	0.30
05/10 1970	2200	0.30
08/30 1971	700	0.50
08/02 1972	200	0.20
08/06 1973	200	0.20
06/20 1974	1800	0.70
06/19 1975	700	0.30
08/03 1976	1900	0.30
06/13 1977	1500	0.30
07/03 1978	2000	0.30
06/17 1979	2100	0.30
05/09 1980	2300	0.30
05/20 1981	1800	0.40
08/01 1982	2300	0.20
06/27 1983	2000	0.90
06/20 1984	2400	0.30
09/12 1985	400	0.30
06/28 1986	2300	0.70
08/14 1987	300	0.20
06/28 1988	1600	0.30
07/12 1989	2400	0.80
08/19 1990	2100	0.80

Max =	0.90
Min =	0.15
years =	43
Mean =	0.387
s =	0.193
alpha =	0.151
beta =	0.300

year	rain
2	0.35
5	0.53
10	0.64
25	0.78
50	0.89
100	0.99

Glasgow WSO Airport, MT 3558

Date	Time	Rain, in.
09/04 1957	1600	0.11
06/09 1958	1500	0.64
06/22 1959	1900	0.65
07/22 1960	2400	0.24
07/30 1961	1700	0.87
07/13 1962	1800	1.01
08/25 1963	2400	0.83
08/19 1964	2000	0.24
06/14 1965	2300	0.90
08/19 1966	1900	0.94
09/11 1967	2200	0.32
06/24 1968	1000	0.38
07/07 1969	100	0.62
07/22 1970	1500	0.41
06/03 1971	1900	0.54
08/13 1972	2200	0.94
06/30 1973	1900	0.81
07/07 1974	2100	0.62
07/01 1975	100	1.50
07/01 1976	2300	0.67
09/17 1977	1600	0.31
07/31 1978	2100	0.62
08/21 1979	1600	0.53
06/12 1980	2200	0.54
07/13 1981	2000	1.28
05/27 1982	2400	0.33
07/10 1983	300	0.96
06/11 1984	1800	0.32
08/02 1985	1900	1.98
05/04 1986	2100	0.39
07/29 1987	400	0.65
07/04 1988	400	0.57
07/16 1989	2300	0.62
08/25 1990	100	0.68

Max =	1.98
Min =	0.11
years =	34
Mean =	0.677
s =	0.379
alpha =	0.295
beta =	0.507

year	rain
2	0.61
5	0.95
10	1.17
25	1.45
50	1.66
100	1.87

Glendive, MT 3581

Date		Time	Rain, in.		
08/12	1949	1100	0.27	Max =	2.60
06/24	1950	2200	0.57	Min =	0.27
08/25	1951	2000	0.81	years =	42
06/19	1952	2000	0.33		
07/20	1953	1800	0.86	Mean =	0.715
08/15	1954	2100	0.92	s =	0.472
06/26	1955	2300	0.47		
06/18	1956	200	1.77	alpha =	0.368
07/23	1957	200	0.52	beta =	0.503
06/03	1958	2000	0.33		
06/26	1959	1800	0.55	year	rain
06/20	1960	1700	1.33	2	0.64
06/29	1961	2000	1.15	5	1.05
07/18	1962	1900	1.50	10	1.33
06/05	1963	1900	0.45	25	1.68
06/18	1964	1100	0.49	50	1.94
08/06	1965	200	1.23	100	2.20
05/14	1966	2000	0.32		
06/08	1967	1200	0.85		
05/13	1968	2100	0.77		
07/01	1969	2200	0.75		
06/14	1970	1300	1.18		
06/18	1971	2100	0.65		
06/08	1972	1700	0.40		
09/01	1973	1200	0.28		
08/20	1974	600	0.73		
05/06	1975	1800	0.40		
07/02	1976	900	0.55		
08/22	1977	800	0.30		
06/24	1978	2200	0.70		
07/25	1979	2300	0.30		
06/12	1980	2400	0.70		
08/01	1981	1700	0.80		
09/27	1982	600	0.30		
07/18	1983	300	0.70		
06/20	1984	2200	0.40		
08/02	1985	2000	0.30		
09/24	1986	2100	0.70		
06/18	1987	2000	0.30		
09/18	1988	100	0.30		
08/30	1989	1900	2.60		
06/27	1990	2300	1.20		

Great Falls WSCMO Airport, MT 3751

Date		Time	Rain, in.		
07/20	1948	1600	0.46	Max =	1.38
05/17	1949	600	0.41	Min =	0.25
08/09	1950	2000	1.38	years =	43
06/22	1951	1600	0.56		
05/03	1952	2400	0.25	Mean =	0.554
06/07	1953	1500	0.41	s =	0.252
08/21	1954	600	0.36		
07/22	1955	1600	0.86	alpha =	0.196
07/11	1956	200	0.44	beta =	0.441
06/19	1957	1800	0.36		
06/06	1958	2200	0.40	year	rain
05/18	1959	400	0.26	2	0.51
07/09	1960	1800	0.31	5	0.74
06/29	1961	1500	0.50	10	0.88
08/22	1962	1600	0.30	25	1.07
07/05	1963	2100	0.62	50	1.21
07/02	1964	1800	0.38	100	1.34
06/24	1965	1900	0.60		
07/12	1966	1800	0.60		
07/03	1967	1900	0.48		
08/14	1968	1800	0.38		
06/25	1969	1900	0.32		
08/02	1970	1700	0.62		
05/05	1971	2100	0.31		
06/09	1972	1600	0.58		
04/20	1973	1400	0.26		
06/20	1974	1800	0.58		
06/30	1975	2000	0.82		
06/06	1976	2000	0.80		
07/10	1977	1700	0.34		
06/18	1978	2000	0.58		
06/16	1979	1900	0.54		
05/25	1980	1300	0.67		
08/19	1981	1800	0.50		
06/28	1982	2000	1.14		
08/10	1983	1900	0.67		
05/15	1984	1500	0.47		
05/28	1985	1500	0.80		
06/05	1986	1900	0.42		
06/06	1987	1500	0.42		
07/05	1988	1600	0.69		
07/15	1989	2000	0.78		
05/28	1990	1600	1.20		

Havre WSO Airport, MT 3996

Date		Time	Rain, in.		
06/29	1961	1800	0.57	Max =	1.23
06/12	1962	1300	0.62	Min =	0.15
07/03	1963	2400	0.36	years =	29
06/05	1964	1700	0.30		
08/23	1965	1800	1.23	Mean =	0.453
07/03	1966	100	0.40	s =	0.235
04/20	1967	1000	0.15		
06/07	1968	1800	0.61	alpha =	0.183
07/02	1969	2000	0.46	beta =	0.347
06/12	1970	2200	0.40		
08/31	1971	1700	0.29	year	rain
08/23	1972	1700	0.58	2	0.41
10/02	1973	1100	0.30	5	0.62
05/13	1974	300	0.27	10	0.76
07/01	1975	2200	0.46	25	0.93
06/06	1976	2200	0.44	50	1.06
05/25	1977	1300	0.19	100	1.19
05/29	1978	1500	0.60		
07/04	1979	300	0.24		
05/24	1980	2300	0.32		
07/24	1981	2100	0.37		
08/11	1982	200	0.55		
05/09	1983	1700	0.32		
05/27	1984	1300	0.28		
08/03	1985	200	0.24		
07/16	1986	1700	1.00		
06/20	1987	900	0.50		
08/22	1989	2100	0.73		
07/25	1990	1300	0.35		

Hays, MT 4020

Date		Time	Rain, in.		
06/29	1949	1400	0.39	Max =	0.65
02/16	1950	200	0.13	Min =	0.13
06/05	1951	1900	0.64	years =	16
07/19	1952	400	0.40		
06/12	1953	1900	0.65	Mean =	0.376
08/05	1954	1600	0.30	s =	0.147
07/25	1955	1800	0.40		
05/26	1956	2100	0.26	alpha =	0.114
08/05	1957	1700	0.25	beta =	0.310
06/08	1958	2300	0.20		
09/21	1959	1500	0.24	year	rain
08/01	1960	1700	0.40	2	0.35
06/12	1961	2000	0.35	5	0.48
06/14	1962	100	0.50	10	0.57
07/08	1963	1800	0.49	25	0.67
06/07	1964	2000	0.41	50	0.76
				100	0.84

Helena WSO, MT 4055

Date	Time	Rain, in.
07/31 1948	2200	0.46
05/29 1949	1900	0.31
08/05 1950	1600	0.49
07/25 1951	1600	0.62
07/19 1952	400	0.21
06/28 1953	1700	0.27
05/30 1954	600	0.36
07/10 1955	1800	0.89
08/24 1956	1900	0.24
08/22 1957	1100	0.45
06/08 1958	1700	0.56
06/21 1959	1400	0.29
08/15 1960	1300	0.28
07/27 1961	2100	0.29
06/13 1962	1800	0.53
08/19 1963	1800	0.28
08/19 1964	700	0.30
06/12 1965	1300	0.36
06/30 1966	1700	0.15
10/02 1967	2400	0.33
08/04 1968	1300	0.79
06/20 1969	1400	0.38
06/27 1970	1800	0.56
07/09 1971	1400	0.20
06/08 1972	2000	0.54
05/25 1973	600	0.21
08/19 1974	2400	0.39
07/03 1975	1900	0.83
06/06 1976	1800	0.46
06/14 1977	1600	0.43
07/02 1978	1900	0.35
06/18 1979	1700	1.23
09/11 1980	700	0.48
05/19 1981	1600	0.39
06/28 1982	1900	0.90
08/21 1983	1400	1.60
05/15 1984	1700	0.41
08/11 1985	600	0.24
08/31 1986	1500	0.44
06/18 1987	1600	0.44
06/26 1988	1400	0.46
07/26 1989	2200	0.26
08/24 1990	1500	0.55

Max =	1.60
Min =	0.15
years =	43
Mean =	0.470
s =	0.279
alpha =	0.218
beta =	0.344

year	rain
2	0.42
5	0.67
10	0.83
25	1.04
50	1.19
100	1.35

Highwood, MT 4120

Date	Time	Rain, in.
04/30 1951	300	0.43
08/05 1952	1700	0.83
06/03 1953	200	0.40
08/30 1954	1900	0.28
07/25 1955	1700	0.55
07/11 1956	200	0.39
06/27 1957	1100	0.35
06/17 1958	2200	0.32
05/18 1959	800	0.29
08/15 1960	1700	0.49
06/29 1961	500	0.24
06/14 1962	2300	0.52
08/25 1963	1800	0.25
05/10 1964	2000	0.35
06/16 1965	1900	1.00
07/02 1966	1900	0.30
10/03 1967	100	0.42
08/14 1968	2000	0.30
05/30 1969	1200	0.36
05/27 1970	1600	0.30
05/05 1971	1800	0.40
08/20 1972	1300	0.23
05/25 1973	1200	0.22
08/19 1974	2000	0.56
06/30 1975	2000	0.65
07/30 1976	2000	0.74
06/20 1977	1700	0.65
06/29 1978	1600	0.33
06/17 1979	2100	0.36
07/05 1980	1800	0.40
08/19 1981	1800	0.90

Max =	1.00
Min =	0.22
years =	31
Mean =	0.445
s =	0.202
alpha =	0.158
beta =	0.354

year	rain
2	0.41
5	0.59
10	0.71
25	0.86
50	0.97
100	1.08

Hilger, MT 4143

Date	Time	Rain, in.
07/10 1948	2100	0.51
08/16 1949	1500	0.45
07/30 1950	1200	0.46
05/28 1951	1100	0.34
05/03 1952	2100	0.43
06/12 1953	1800	0.79
06/27 1954	1700	0.33
07/25 1955	1500	0.45
06/15 1956	2000	1.16
05/11 1957	1300	0.38
06/19 1958	1400	0.45
05/16 1959	1700	0.47
07/22 1960	2000	0.41
07/29 1961	2100	0.91
05/19 1962	1800	0.85
08/25 1963	1800	0.26
06/16 1964	1600	0.65
06/24 1965	2300	1.04
06/24 1966	1600	0.48
07/21 1967	1500	0.35
07/12 1968	1800	0.46
07/05 1969	1600	0.35
08/01 1970	1900	0.25
06/02 1971	1800	0.23
08/16 1972	1900	1.25
06/14 1973	1600	0.36
08/19 1974	2000	0.50
06/07 1975	2300	0.21
08/07 1976	1900	0.60
06/20 1977	1900	0.50
07/03 1978	2100	0.60
06/16 1979	1100	0.50
05/24 1980	2100	0.30
08/04 1981	700	0.30
07/07 1982	1800	0.30
07/09 1983	2300	0.60
06/15 1984	1200	0.40
07/23 1985	2000	0.40
04/22 1986	1800	0.30
06/18 1987	2100	0.30
07/03 1988	1700	0.50
08/24 1989	1600	0.40
05/24 1990	1700	1.00

Max =	1.25
Min =	0.21
years =	43
Mean =	0.507
s =	0.250
alpha =	0.195
beta =	0.394

year	rain
2	0.47
5	0.69
10	0.83
25	1.02
50	1.16
100	1.29

Holter Dam, MT 4241

Date	Time	Rain, in.
07/19 1948	2000	0.20
05/29 1949	2000	0.48
07/10 1950	400	0.37
04/30 1951	1000	0.24
05/14 1952	700	0.34
06/02 1953	800	0.20
06/28 1954	1500	0.14
07/11 1955	2000	0.56
06/01 1956	2200	0.46
06/19 1957	1700	0.40
08/03 1958	1600	0.53
06/21 1959	1600	0.22
08/01 1960	1300	0.32
05/30 1961	1500	0.24
05/21 1962	500	0.22
09/16 1963	700	0.24
07/30 1964	1300	0.35
07/07 1965	1400	1.38
07/01 1966	1800	0.70
06/21 1967	1600	0.40
05/14 1968	2100	0.20
04/07 1969	800	1.40
06/27 1970	1900	0.70
06/03 1971	1800	0.40
08/02 1972	100	0.20
09/07 1973	2000	0.40
08/20 1974	400	0.20
04/26 1975	600	0.30
07/12 1976	700	0.30
06/14 1977	1300	0.40
05/22 1978	700	0.90
07/03 1979	2000	0.70
05/25 1980	1300	0.30
05/21 1981	2400	0.40
07/01 1982	1700	0.30
07/01 1983	1900	0.40
11/30 1984	2400	0.20
05/31 1985	2100	0.30
07/16 1986	1600	0.30
06/18 1987	1700	0.40
07/04 1988	600	0.50
06/15 1989	1700	0.90
08/19 1990	1800	0.40

Max =	1.40
Min =	0.14
years =	43
Mean =	0.430
s =	0.279
alpha =	0.218
beta =	0.304

year	rain
2	0.38
5	0.63
10	0.79
25	1.00
50	1.15
100	1.31

Iliad, MT 4368

Date	Time	Rain, in.
07/19 1948	400	0.36
07/06 1949	1800	0.85
08/05 1950	1900	0.29
08/29 1951	2100	0.50
05/02 1952	1500	0.37
06/09 1953	2200	0.35
08/05 1954	1500	0.41
07/25 1955	1700	0.45
06/15 1956	2000	0.70
08/17 1957	1800	0.29
07/08 1958	1700	0.35
05/01 1959	2300	0.50
08/01 1960	1500	0.91
07/06 1961	2100	0.41
06/12 1962	1700	0.59
07/09 1963	2100	0.54
07/02 1964	2100	0.39
06/25 1965	100	0.70
06/02 1966	2200	0.29
09/11 1967	2400	0.25
08/14 1968	2000	1.25
06/25 1969	1900	0.29
06/12 1970	1700	0.31
06/03 1971	1800	0.35
08/02 1972	1500	0.18
10/02 1973	1000	0.15
07/10 1974	2400	0.37
07/01 1975	2100	0.61
07/06 1976	2300	0.65
07/10 1977	1200	0.22
08/22 1978	1800	0.33
06/20 1979	1700	0.12
05/25 1980	1100	0.33
03/29 1981	2400	0.22
05/18 1982	2100	0.53
07/18 1983	2300	0.38
05/14 1984	1900	0.20
08/03 1985	700	0.43
07/15 1986	1900	0.41
03/13 1987	1900	0.18
07/03 1988	1000	0.30

Max =	1.25
Min =	0.12
years =	41
Mean =	0.422
s =	0.224
alpha =	0.174
beta =	0.322

year	rain
2	0.39
5	0.58
10	0.71
25	0.88
50	1.00
100	1.12

Ismay, MT 4442

Date	Time	Rain, in.
08/07 1948	2200	0.80
05/19 1949	2200	0.55
08/12 1950	1100	0.72
08/23 1951	2200	1.04
07/19 1952	1700	0.50
06/26 1953	1800	0.61
08/16 1954	2400	0.67
05/03 1955	200	0.78
06/24 1956	1900	0.86
08/17 1957	2000	0.60
06/30 1958	1600	1.26
06/18 1959	400	0.57
07/11 1960	2100	1.26
09/10 1961	800	0.23
06/01 1962	1900	0.56
07/09 1963	1000	0.53
06/07 1964	2000	1.30
08/04 1965	1500	0.60
07/15 1966	200	0.55
06/11 1967	1900	0.38
06/23 1968	1100	0.37
07/18 1969	1800	0.75
07/13 1970	2100	0.92
06/15 1971	2100	0.78
06/23 1972	2000	1.00
09/03 1973	300	0.40
06/21 1974	1400	1.18
06/22 1975	1900	0.55
08/24 1976	2200	0.69
06/16 1977	1800	1.04
07/18 1978	1900	0.70
07/08 1979	1800	0.38
08/31 1980	1600	0.44
08/02 1981	1900	0.81
05/19 1982	2100	0.42
06/21 1983	1900	0.48
06/21 1984	2300	0.72
08/07 1985	1900	0.87
07/26 1986	2200	0.46
06/19 1987	1900	0.44
07/04 1988	1900	1.20
06/23 1989	2100	0.50
07/26 1990	300	0.30

Max =	1.30
Min =	0.23
years =	43
Mean =	0.692
s =	0.279
alpha =	0.218
beta =	0.567

year	rain
2	0.65
5	0.89
10	1.06
25	1.26
50	1.42
100	1.57

Joplin 1 N, MT 4512

Date	Time	Rain, in.		
07/14 1948	1500	0.21	Max =	1.45
05/16 1949	2000	0.33	Min =	0.10
08/04 1950	2300	0.58	years =	43
07/05 1951	2200	0.35		
09/05 1952	1400	0.31	Mean =	0.463
06/08 1953	100	0.35	s =	0.284
06/26 1954	2100	1.18		
07/06 1955	1400	0.42	alpha =	0.221
08/09 1956	2400	0.45	beta =	0.335
08/30 1957	1400	0.54		
07/26 1958	300	0.29	year	rain
06/16 1959	2200	0.27	2	0.42
05/25 1960	400	0.17	5	0.67
07/06 1961	2100	0.20	10	0.83
06/12 1962	1800	1.45	25	1.04
06/28 1963	1700	0.87	50	1.20
06/15 1964	1300	0.34	100	1.35
06/16 1965	400	0.50		
06/02 1966	2100	0.58		
04/27 1967	600	0.10		
09/20 1968	800	0.23		
07/02 1969	1900	0.60		
07/13 1970	1700	0.51		
02/04 1971	1800	0.13		
06/03 1972	1700	0.52		
09/25 1973	1800	0.24		
07/08 1974	1900	0.48		
08/20 1975	400	0.33		
06/06 1976	2100	0.42		
05/10 1977	1800	1.00		
04/17 1978	100	0.16		
08/31 1979	800	0.40		
05/25 1980	1300	0.90		
07/13 1981	2300	0.60		
06/28 1982	2000	0.40		
06/28 1983	2200	0.40		
09/09 1984	2000	0.20		
09/11 1985	300	0.90		
08/12 1986	1400	0.40		
05/25 1987	1200	0.40		
09/11 1988	500	0.30		
08/16 1989	200	0.30		
05/24 1990	1400	0.60		

Kings Hill, MT 4663

Date	Time	Rain, in.		
08/21 1940	1500	0.40	Max =	2.17
07/25 1941	1600	0.46	Min =	0.20
08/06 1942	1200	0.39	years =	22
10/16 1947	1800	0.20		
01/31 1948	900	2.17	Mean =	0.469
05/19 1949	2000	0.27	s =	0.409
08/03 1950	1600	0.34		
04/30 1951	800	0.40	alpha =	0.319
05/14 1952	1700	0.45	beta =	0.285
05/21 1953	1800	0.31		
06/26 1954	2000	0.40	year	rain
08/14 1955	1700	0.46	2	0.40
05/10 1956	500	0.25	5	0.76
06/06 1957	1700	0.28	10	1.00
05/31 1958	2200	0.40	25	1.30
05/01 1959	2100	0.25	50	1.53
08/15 1960	1500	0.33	100	1.75
07/05 1961	2100	0.26		
06/03 1962	1200	0.55		
04/07 1963	2100	0.40		
06/11 1964	1700	0.40		
06/16 1965	1800	0.95		

Lavina, MT 4904

Date	Time	Rain, in.		
07/10 1948	2000	0.93	Max =	1.25
07/05 1949	1900	0.62	Min =	0.19
07/10 1950	2000	0.30	years =	42
08/29 1951	1900	0.82		
08/14 1952	1800	0.20	Mean =	0.514
08/22 1953	1600	0.66	s =	0.250
08/15 1954	1800	0.51		
07/12 1955	100	0.46	alpha =	0.195
06/24 1956	1400	0.36	beta =	0.402
06/06 1957	1900	0.45		
05/31 1958	2000	0.40	year	rain
06/25 1959	2200	0.44	2	0.47
07/14 1960	2200	0.40	5	0.69
07/08 1961	2100	0.51	10	0.84
06/19 1962	1600	0.67	25	1.02
07/29 1963	1700	0.47	50	1.16
06/21 1964	2100	0.20	100	1.30
09/11 1965	2000	0.20		
07/02 1966	2300	1.24		
06/06 1967	2100	1.25		
07/15 1968	2000	0.68		
06/20 1969	1700	0.38		
09/08 1970	1400	0.19		
08/31 1971	600	0.40		
08/02 1972	1800	0.47		
08/22 1973	1800	0.83		
08/19 1975	1900	0.61		
06/07 1976	1700	0.47		
06/19 1977	1800	0.48		
09/08 1978	2200	0.68		
05/27 1979	1600	0.49		
05/30 1980	600	0.25		
06/27 1981	2200	0.50		
06/22 1982	1700	0.47		
07/09 1983	2300	0.26		
08/06 1984	1700	0.28		
09/11 1985	2000	0.50		
08/31 1986	1600	0.57		
08/23 1987	2000	0.50		
05/07 1988	600	0.20		
11/13 1989	1100	0.40		
08/19 1990	2000	0.90		

Lewistown 2 SW, MT 4983

Date	Time	Rain, in.		
06/01 1954	2300	0.15	Max =	1.33
06/18 1955	1600	0.35	Min =	0.15
06/16 1965	2200	0.99	years =	43
06/24 1966	1600	0.71		
09/13 1967	1400	0.31	Mean =	0.548
08/14 1968	2000	0.36	s =	0.272
07/18 1969	700	0.50		
05/19 1970	1800	0.40	alpha =	0.212
08/03 1971	1900	0.25	beta =	0.425
08/14 1972	1900	0.80		
06/14 1973	1600	1.00	year	rain
05/13 1974	600	0.50	2	0.50
06/29 1975	2000	1.00	5	0.74
09/18 1976	1300	0.50	10	0.90
07/26 1977	500	0.60	25	1.10
07/18 1978	1200	0.40	50	1.25
06/18 1979	2000	0.40	100	1.40
10/23 1980	1200	0.40		
05/20 1981	1500	0.70		
07/13 1982	2200	0.30		
07/09 1983	2200	0.60		
06/06 1984	1800	0.40		
08/11 1985	1100	0.30		
05/04 1986	1700	0.70		
06/19 1987	1300	0.50		
06/22 1988	1700	0.30		
07/27 1989	1800	0.40		
08/24 1990	1900	0.30		

Lewistown Arpt, MT 4985

07/19 1948	1600	0.55	
08/19 1949	1600	0.84	
08/12 1950	1000	0.23	
06/17 1951	1600	0.32	
08/08 1952	300	0.28	
08/21 1953	1900	0.59	
06/15 1956	2000	0.81	
07/27 1957	1700	0.25	
07/29 1958	1200	0.33	
06/17 1959	100	0.64	
08/03 1960	1900	0.95	
07/20 1961	1400	1.00	
05/20 1962	2000	1.33	
06/14 1963	1400	0.83	
06/08 1964	100	0.48	

Lincoln Ranger Stn, MT 5040

Date	Time	Rain, in.		
08/06 1971	2000	0.60	Max =	1.00
06/09 1972	1800	0.60	Min =	0.20
04/24 1973	500	0.30	years =	20
03/03 1974	800	0.30		
08/19 1975	2300	0.40	Mean =	0.400
06/10 1976	1700	0.30	s =	0.195
09/16 1977	1900	0.30		
07/31 1978	1300	0.40	alpha =	0.152
08/21 1979	1600	0.50	beta =	0.312
06/12 1980	1600	0.60		
08/15 1981	1600	1.00	year	rain
06/29 1982	2100	0.30	2	0.37
06/29 1983	1900	0.40	5	0.54
06/20 1984	2300	0.50	10	0.65
08/15 1985	1700	0.30	25	0.80
07/04 1986	2000	0.20	50	0.90
06/23 1987	1000	0.40	100	1.01
05/07 1988	800	0.20		
08/12 1989	1900	0.20		
08/19 1990	1800	0.20		

Livingston Mission Field, MT 5086

Date	Time	Rain, in.		
07/15 1942	1800	0.25	Max =	2.63
08/07 1943	1800	0.22	Min =	0.14
05/17 1944	2100	0.34	years =	49
11/09 1945	1000	0.67		
07/03 1946	1600	0.23	Mean =	0.416
07/31 1947	1700	1.25	s =	0.377
06/13 1948	2100	0.79		
09/30 1949	2100	0.53	alpha =	0.294
07/03 1950	2200	0.42	beta =	0.247
06/12 1951	1600	0.14		
06/06 1952	2200	0.55	year	rain
06/20 1953	200	0.30	2	0.35
05/21 1954	1700	0.25	5	0.69
06/16 1955	1800	0.20	10	0.91
06/24 1956	1200	0.29	25	1.19
06/08 1957	1900	0.49	50	1.39
07/03 1958	2000	0.59	100	1.60
05/26 1959	700	0.21		
06/19 1960	1600	0.25		
09/20 1961	1500	0.21		
08/29 1962	1800	0.62		
06/14 1963	1200	0.25		
08/28 1964	2300	0.23		
07/01 1965	1600	0.33		
08/19 1966	2000	0.31		
10/05 1967	1600	0.27		
09/27 1968	1700	0.14		
05/20 1969	2400	0.30		
07/13 1970	1300	0.43		
07/02 1971	1400	0.28		
06/20 1972	2400	0.28		
08/24 1973	900	0.20		
08/07 1974	1800	0.38		
09/01 1975	2300	0.34		
10/02 1976	2300	0.35		
06/09 1977	1600	0.65		
07/07 1978	2300	0.40		
08/24 1979	1600	2.63		
08/13 1980	2100	0.25		
05/22 1981	1900	0.35		
08/22 1982	1900	0.27		
08/14 1983	1100	0.39		
07/07 1984	1200	0.48		
07/17 1985	1600	0.27		
06/29 1986	400	0.32		
09/26 1987	1900	0.30		
05/06 1988	1900	0.30		
06/10 1989	1100	0.30		
05/24 1990	1500	0.60		

Lodge Grass, MT 5106

Date		Time	Rain, in.		
05/17	1949	1300	0.25	Max =	1.81
06/24	1950	1900	0.63	Min =	0.19
08/24	1951	1600	0.80	years =	42
09/07	1952	1700	0.30		
08/02	1953	1100	0.53	Mean =	0.543
07/16	1954	2200	0.51	s =	0.295
07/28	1955	1700	0.92		
05/27	1956	2100	0.43	alpha =	0.230
06/06	1957	2100	0.54	beta =	0.410
07/03	1958	200	1.81		
06/23	1959	2200	0.39	year	rain
06/15	1960	1800	0.27	2	0.49
09/09	1961	2300	0.19	5	0.76
07/27	1962	1500	0.65	10	0.93
06/14	1963	2000	0.51	25	1.15
08/29	1964	200	0.81	50	1.31
05/27	1965	1600	0.38	100	1.47
06/22	1966	1000	0.25		
06/14	1967	1600	1.04		
08/14	1968	2200	0.50		
07/15	1969	1800	1.00		
06/16	1970	2000	0.60		
06/01	1971	2000	0.40		
05/18	1972	1800	0.50		
09/07	1973	1800	0.70		
07/02	1974	1800	0.50		
06/08	1975	900	0.20		
06/14	1976	300	0.20		
07/26	1977	1500	0.40		
05/17	1978	2300	0.90		
07/28	1979	2100	0.60		
05/24	1980	2100	0.40		
07/25	1981	900	0.40		
06/17	1982	1500	0.50		
09/19	1983	1200	0.20		
04/27	1984	1200	0.30		
05/27	1985	1800	0.60		
06/03	1986	1900	0.70		
07/17	1987	2000	0.40		
06/29	1988	2000	0.50		
05/11	1989	2100	0.50		
05/30	1990	1200	0.60		

Logan, MT 5122

Date		Time	Rain, in.		
09/24	1971	500	0.20	Max =	0.80
08/23	1972	1000	0.60	Min =	0.20
08/04	1973	1600	0.30	years =	20
05/30	1974	1600	0.30		
05/06	1975	600	0.80	Mean =	0.415
07/18	1976	1200	0.60	s =	0.211
06/20	1977	1500	0.60		
09/12	1978	200	0.20	alpha =	0.164
06/18	1979	1900	0.20	beta =	0.320
05/25	1980	1900	0.20		
07/06	1981	1300	0.30	year	rain
06/13	1982	1700	0.80	2	0.38
04/03	1983	1000	0.60	5	0.57
08/31	1984	1100	0.30	10	0.69
05/26	1985	600	0.20	25	0.85
08/23	1986	1700	0.50	50	0.96
06/19	1987	1600	0.70	100	1.08
07/04	1988	1600	0.30		
06/16	1989	1700	0.30		
08/10	1990	1800	0.30		

Martinsdale 3 NNW, MT 5387

Date		Time	Rain, in.		
06/03	1941	2100	0.19	Max =	1.57
09/12	1942	1800	0.21	Min =	0.19
08/02	1943	1500	0.65	years =	50
06/07	1944	1300	0.48		
06/03	1945	2400	0.30	Mean =	0.462
07/02	1946	1600	0.26	s =	0.267
07/22	1947	1600	0.42		
07/10	1948	1900	0.75	alpha =	0.208
09/30	1949	1500	1.57	beta =	0.342
07/03	1950	1500	0.45		
08/23	1951	1800	0.96	year	rain
07/12	1952	200	0.23	2	0.42
08/15	1953	1600	0.33	5	0.65
08/26	1954	1300	0.24	10	0.81
06/15	1955	2200	0.40	25	1.01
06/20	1956	1700	0.97	50	1.15
08/27	1957	2400	0.65	100	1.30
05/31	1958	1900	0.27		
06/06	1959	1500	0.42		
08/07	1960	1000	0.20		
07/08	1961	2100	0.35		
06/09	1962	1500	0.47		
05/25	1963	1800	0.48		
05/01	1964	2000	0.29		
07/29	1965	1400	0.53		
07/02	1966	2100	0.69		
05/29	1967	1800	0.24		
09/19	1968	2300	0.50		
09/12	1969	1300	0.50		
07/28	1970	1600	0.80		
08/02	1971	1600	0.30		
06/23	1972	1500	0.30		
09/15	1973	1500	0.20		
05/12	1974	1900	0.30		
07/09	1975	1400	0.40		
09/24	1976	1400	0.60		
06/20	1977	1700	0.30		
07/04	1978	800	0.40		
06/18	1979	2000	0.30		
10/16	1980	1600	0.40		
08/14	1981	1900	0.30		
06/16	1982	1600	0.70		
06/05	1983	1500	0.30		
08/19	1984	2200	1.10		
08/03	1985	100	0.30		
06/07	1986	2400	0.40		
06/09	1987	1700	0.70		
07/04	1988	2200	0.40		
09/17	1989	1700	0.20		
08/17	1990	1900	0.40		

Miles City, MT 5685

Date		Time	Rain, in.		
07/19	1948	2100	1.35	Max =	1.45
07/20	1949	1400	0.45	Min =	0.10
07/16	1950	1000	0.49	years =	36
08/12	1951	2000	0.93		
06/27	1952	700	0.32	Mean =	0.590
07/23	1953	500	1.30	s =	0.334
08/16	1954	2200	0.95		
05/03	1955	200	0.41	alpha =	0.260
08/02	1956	2300	0.70	beta =	0.440
08/15	1957	2400	0.24		
07/07	1958	2200	0.33	year	rain
06/26	1959	1700	0.64	2	0.54
05/27	1960	1900	0.23	5	0.83
07/29	1961	2200	0.95	10	1.02
06/01	1962	1800	0.75	25	1.27
07/05	1963	1800	0.45	50	1.45
06/18	1964	400	1.45	100	1.64
07/09	1965	1900	1.00		
07/28	1966	900	0.55		
05/10	1967	900	0.41		
08/18	1968	700	0.65		
07/20	1969	500	0.75		
09/08	1970	1700	0.43		
05/14	1971	2400	0.10		

Miles City FAA Airport, MT 5690

08/22	1973	2200	0.57		
10/31	1974	300	0.30		
07/07	1975	2000	0.28		
06/06	1976	2200	0.70		
06/14	1977	300	0.37		
08/31	1979	2100	0.16		
06/11	1980	2200	0.56		
06/13	1981	300	0.26		
06/04	1982	1700	0.33		
07/29	1983	1900	0.40		
06/15	1984	1700	0.71		
08/02	1985	1700	0.77		

Millegan, MT 5706

Date		Time	Rain, in.		
08/04	1948	1800	0.88	Max =	2.00
09/30	1949	2100	0.35	Min =	0.20
03/06	1950	1200	0.22	years =	43
08/29	1951	2400	0.33		
06/06	1952	1800	0.50	Mean =	0.511
06/03	1953	1200	0.35	s =	0.345
08/15	1954	1400	0.30		
07/04	1955	2100	0.28	alpha =	0.269
06/16	1956	300	0.20	beta =	0.355
06/06	1957	1300	0.33		
07/08	1958	1500	0.30	year	rain
06/15	1959	1800	0.26	2	0.45
08/25	1960	100	0.31	5	0.76
06/11	1961	1800	0.39	10	0.96
07/12	1962	2100	0.39	25	1.22
08/10	1963	2000	0.33	50	1.40
06/16	1964	1400	0.45	100	1.59
08/05	1965	2000	0.49		
07/12	1966	1800	1.07		
07/03	1967	2000	0.59		
05/29	1968	1300	0.64		
04/26	1969	600	1.10		
06/27	1970	1800	0.50		
08/31	1971	1400	0.30		
07/24	1972	1700	0.40		
09/07	1973	2000	0.20		
08/07	1974	2300	0.30		
08/20	1975	800	0.50		
06/06	1976	1900	0.50		
09/29	1977	1900	0.30		
09/11	1978	1900	0.30		
06/17	1979	1900	0.50		
06/14	1980	1700	1.30		
08/04	1981	1500	0.70		
07/25	1982	1600	0.40		
12/17	1983	900	2.00		
05/15	1984	1500	0.30		
08/02	1985	1200	0.70		
06/28	1986	2000	0.40		
07/02	1987	1700	0.30		
05/06	1988	2400	0.40		
07/12	1989	1800	1.00		
08/18	1990	2100	0.60		

Wolt 6 SW, MT 5791

Date		Time	Rain, in.		
07/19	1948	1800	0.52	Max =	1.77
07/27	1949	1700	0.65	Min =	0.16
08/12	1950	1200	0.66	years =	43
06/12	1951	1700	0.33		
09/10	1952	2000	0.55	Mean =	0.453
05/28	1953	1100	0.20	s =	0.321
06/10	1954	600	0.24		
06/16	1955	2100	0.40	alpha =	0.250
08/17	1956	1700	1.26	beta =	0.309
06/02	1957	1600	1.13		
07/02	1958	1700	0.65	year	rain
08/06	1959	2100	0.29	2	0.40
07/28	1960	1800	0.43	5	0.68
09/18	1961	1800	0.25	10	0.87
07/13	1962	1600	0.44	25	1.11
05/10	1963	2400	0.30	50	1.29
06/08	1964	1700	0.33	100	1.46
06/16	1965	1900	0.83		
09/13	1966	400	0.27		
06/17	1967	1800	0.49		
08/09	1968	100	0.27		
06/25	1969	900	0.35		
05/23	1970	1500	1.77		
04/18	1971	700	0.16		
08/02	1972	1900	0.78		
09/07	1973	1700	0.22		
07/02	1974	2100	0.29		
06/18	1975	1300	0.25		
05/14	1976	1900	0.21		
08/26	1977	1800	0.30		
09/07	1978	2100	0.40		
09/11	1979	1800	0.23		
05/23	1980	2300	0.26		
05/21	1981	1800	0.39		
05/18	1982	700	0.27		
07/09	1983	2300	0.22		
07/20	1984	1500	0.26		
05/25	1985	2300	0.28		
06/06	1986	100	0.67		
05/19	1987	1900	0.20		
05/07	1988	500	0.30		
07/29	1989	2200	0.40		
05/24	1990	1700	0.80		

Neihart, MT 6001

Date	Time	Rain, in.		
09/21 1965	1300	0.20	Max =	0.90
06/30 1966	1600	0.83	Min =	0.20
Neihart 8 NNW, MT 6008			years =	26
07/26 1967	2000	0.41		
05/29 1968	300	0.69	Mean =	0.472
06/25 1969	1900	0.40	s =	0.177
05/10 1970	1900	0.33		
08/04 1971	600	0.20	alpha =	0.138
06/15 1972	1600	0.60	beta =	0.392
06/30 1973	1600	0.40		
08/19 1974	1900	0.60	year	rain
05/07 1975	300	0.50	2	0.44
08/23 1976	1400	0.50	5	0.60
06/20 1977	1600	0.50	10	0.70
07/06 1978	1600	0.50	25	0.83
06/18 1979	2200	0.40	50	0.93
06/14 1980	1800	0.40	100	1.03
05/21 1981	2100	0.40		
05/18 1982	1700	0.20		
08/04 1983	1900	0.50		
03/05 1984	2400	0.30		
08/02 1985	1300	0.40		
08/30 1986	1400	0.40		
07/29 1987	2000	0.40		
07/04 1988	1800	0.90		
06/15 1989	1800	0.60		
05/24 1990	1600	0.70		

Reedpoint, MT 6946

Date	Time	Rain, in.		
07/19 1948	1700	1.05	Max =	1.06
09/10 1949	2300	0.32	Min =	0.14
06/17 1950	2200	1.06	years =	43
08/11 1951	2000	0.43		
09/10 1952	1900	0.90	Mean =	0.467
07/15 1953	1300	0.38	s =	0.246
05/21 1954	1800	0.30		
05/21 1955	1700	0.45	alpha =	0.192
05/26 1956	1600	0.69	beta =	0.357
05/29 1957	1800	0.67		
07/09 1958	1900	0.72	year	rain
07/03 1959	800	0.21	2	0.43
08/14 1960	1600	0.40	5	0.64
09/10 1961	100	0.16	10	0.79
06/13 1962	1900	0.39	25	0.97
06/07 1963	1400	0.40	50	1.11
04/25 1964	1600	0.27	100	1.24
08/04 1965	1500	0.35		
09/13 1966	500	0.21		
06/06 1967	1600	0.72		
06/09 1968	600	0.30		
06/06 1969	2000	0.46		
09/19 1970	1800	0.14		
05/29 1971	1800	0.15		
08/17 1972	1700	0.52		
08/22 1973	1300	0.35		
06/17 1974	2100	0.70		
07/03 1975	1900	0.84		
06/21 1976	1800	0.73		
08/30 1977	1500	0.35		
07/04 1978	1500	0.56		
06/18 1979	1700	0.18		
04/30 1980	1700	0.56		
07/23 1981	1900	0.36		
05/26 1982	1800	0.43		
08/23 1983	1800	0.64		
06/11 1984	300	0.19		
09/02 1985	1800	0.20		
04/26 1986	300	0.35		
05/24 1987	1600	0.51		
06/28 1988	1800	0.90		
10/01 1989	300	0.20		
08/18 1990	1800	0.40		

Reserve 14 W, MT 6976

Date		Time	Rain, in.		
07/12	1948	200	0.35	Max =	2.15
05/17	1949	600	0.35	Min =	0.14
07/10	1950	1900	1.10	years =	33
08/30	1951	400	0.70		
06/30	1953	1300	0.98	Mean =	0.622
08/26	1954	1800	0.35	s =	0.398
07/06	1955	2100	0.41		
06/29	1956	100	0.43	alpha =	0.310
08/30	1957	1300	0.49	beta =	0.443
07/14	1958	1300	0.28		
06/15	1959	2200	0.91	year	rain
06/20	1960	1800	0.85	2	0.56
06/12	1961	2300	1.40	5	0.91
07/18	1962	2000	0.40	10	1.14
06/03	1963	1900	0.74	25	1.44
06/07	1964	2300	0.35	50	1.65
08/24	1965	1500	0.49	100	1.87
07/01	1966	200	0.99		
06/13	1967	2100	0.34		
07/15	1968	2400	0.68		
07/06	1969	300	0.36		
07/27	1970	2100	0.55		
07/11	1971	400	0.53		
07/25	1972	300	0.45		
06/02	1973	1200	0.18		
08/08	1974	500	0.86		
07/15	1975	2100	0.54		
06/11	1976	2300	0.76		
07/09	1977	2300	0.44		
07/03	1978	2400	2.15		
06/22	1979	1500	0.75		
06/13	1980	100	0.24		
07/11	1981	2300	0.14		

Ridge 2 WSW, MT 7028

Date		Time	Rain, in.		
10/12	1951	1900	0.25	Max =	1.65
09/07	1952	1500	0.40	Min =	0.25
06/14	1953	2100	0.54	years =	22
08/05	1954	1900	0.80		
07/12	1955	1100	0.43	Mean =	0.670
07/07	1956	200	0.45	s =	0.308
05/30	1957	1600	1.65		
06/03	1958	1900	0.55	alpha =	0.240
06/24	1959	100	0.32	beta =	0.531
06/07	1960	2100	0.75		
07/05	1961	1300	1.05	year	rain
05/18	1962	1200	0.60	2	0.62
09/09	1963	1100	0.91	5	0.89
06/30	1964	1900	0.63	10	1.07
06/30	1965	2100	0.79	25	1.30
07/13	1966	1800	0.72	50	1.47
06/05	1967	1600	0.60	100	1.64
08/23	1968	1200	0.40		
07/17	1969	1600	0.49		
05/27	1970	2300	0.89		
06/09	1971	1700	0.53		
06/10	1972	1800	0.98		

Russell, MT 7258

Date	Time	Rain, in.		
07/19 1948	1400	0.44	Max =	1.00
06/16 1949	1800	0.38	Min =	0.20
08/09 1950	2100	0.76	years =	22
08/30 1951	200	0.28		
07/15 1952	1600	0.26	Mean =	0.459
08/04 1953	800	0.50	s =	0.221
06/26 1954	2100	0.95		
07/06 1955	1300	0.62	alpha =	0.172
07/05 1956	1900	0.40	beta =	0.360
07/30 1957	1500	0.35		
07/29 1958	1900	0.60	year	rain
05/18 1959	200	0.26	2	0.42
07/12 1981	2400	0.40	5	0.62
09/27 1982	700	0.20	10	0.75
06/05 1983	1600	0.50	25	0.91
10/25 1984	2300	0.30	50	1.03
10/03 1985	400	0.20	100	1.15
06/04 1986	1800	0.40		
07/02 1987	200	0.40		
07/11 1988	1800	0.30		
06/10 1989	1600	1.00		
08/20 1990	1900	0.60		

Shelby, MT 7500

Date	Time	Rain, in.		
07/20 1948	1500	0.27	Max =	1.14
05/29 1949	2400	0.18	Min =	0.10
06/17 1950	2300	0.50	years =	41
08/13 1951	2100	0.31		
05/03 1952	2400	0.16	Mean =	0.464
08/04 1953	800	0.60	s =	0.255
09/12 1954	1400	0.42		
07/17 1955	2200	0.39	alpha =	0.199
08/09 1956	2400	0.61	beta =	0.349
08/11 1957	200	0.78		
Shelby Airport, MT 7501			year	rain
07/18 1958	2000	0.40	2	0.42
06/21 1959	1400	0.20	5	0.65
08/06 1960	1600	0.44	10	0.80
07/22 1961	1600	0.35	25	0.98
07/05 1962	2100	0.41	50	1.12
07/04 1963	2000	0.54	100	1.26
06/11 1964	1500	0.85		
07/04 1965	1900	1.14		
07/01 1966	2100	0.69		
07/03 1967	2100	0.40		
06/11 1968	1900	0.22		
06/24 1969	2400	0.27		
07/13 1970	1400	0.70		
08/30 1971	200	0.10		
05/10 1972	1900	0.20		
05/25 1973	800	0.20		
08/10 1974	2400	0.30		
06/23 1975	1800	0.40		
08/05 1976	2200	0.90		
06/15 1977	1500	0.60		
08/22 1978	1600	0.60		
06/17 1979	2300	0.20		
06/12 1980	1900	0.50		
05/20 1981	2000	1.10		
07/25 1982	200	0.60		
03/12 1983	800	0.20		
06/21 1984	1400	0.30		
09/12 1985	700	0.30		
06/04 1986	1700	0.30		
07/26 1987	1600	0.60		
06/28 1988	1900	0.80		

Simms 1 NE, MT 7618

Date	Time	Rain, in.		
05/05 1971	1000	0.30	Max =	1.00
05/22 1972	2000	0.30	Min =	0.30
12/29 1973	2000	0.40	years =	14
07/08 1974	1100	0.30		
08/20 1975	300	0.70	Mean =	0.493
07/12 1976	800	0.30	s =	0.240
06/20 1977	1600	0.80		
01/09 1978	200	0.80	alpha =	0.187
06/16 1979	1900	0.40	beta =	0.385
06/12 1980	1700	1.00		
05/15 1981	1900	0.60	year	rain
06/17 1982	400	0.30	2	0.45
07/25 1983	1500	0.40	5	0.67
06/21 1984	100	0.30	10	0.81
			25	0.98
			50	1.11
			100	1.25

Stanford 2 NE, MT 7858

Date	Time	Rain, in.		
07/03 1949	1700	0.33	Max =	0.97
07/01 1950	2100	0.97	Min =	0.33
08/14 1951	2000	0.39	years =	10
06/06 1952	1800	0.33		
08/04 1953	1200	0.50	Mean =	0.530
07/08 1954	1800	0.70	s =	0.200
08/14 1955	1700	0.47		
08/26 1956	1700	0.43	alpha =	0.156
08/29 1957	1500	0.68	beta =	0.440
06/17 1958	2400	0.50		
			year	rain
			2	0.50
			5	0.67
			10	0.79
			25	0.94
			50	1.05
			100	1.16

Terry 25 NW, MT 8169

Date		Time	Rain, in.		
07/31	1940	2100	0.72	Max =	2.20
08/29	1941	2400	0.60	Min =	0.16
06/05	1942	1300	0.62	years =	51
06/02	1943	200	0.42		
06/16	1944	2100	1.09	Mean =	0.660
06/22	1945	2300	0.62	s =	0.334
07/16	1946	2400	0.90		
07/26	1947	100	0.53	alpha =	0.260
07/11	1948	2400	2.20	beta =	0.510
08/17	1949	1300	0.75		
07/01	1950	600	0.29	year	rain
08/29	1951	200	1.08	2	0.61
08/26	1952	2400	0.34	5	0.90
06/23	1953	2100	1.16	10	1.09
09/05	1954	1700	0.64	25	1.34
07/06	1955	2000	1.08	50	1.52
08/02	1956	2400	0.88	100	1.71
07/14	1957	2100	1.26		
07/10	1958	1000	0.90		
06/09	1959	2200	0.39		
06/20	1960	1500	0.42		
05/30	1961	1500	0.55		
07/18	1962	2000	0.75		
06/05	1963	1900	0.63		
05/03	1964	100	0.30		
06/15	1965	2300	0.80		
06/30	1966	2400	0.60		
06/08	1967	1600	0.54		
06/09	1968	1800	0.52		
07/06	1969	100	0.61		
06/12	1970	1000	0.28		
06/10	1971	300	0.40		
05/19	1972	2200	0.67		
06/18	1973	1000	0.42		
05/28	1974	1200	0.66		
10/08	1975	800	0.41		
07/02	1976	1000	0.99		
06/21	1977	1500	0.44		
07/04	1978	1700	0.67		
06/27	1979	2000	0.65		
08/09	1980	300	0.46		
06/11	1981	2000	0.53		
06/11	1982	1300	0.59		
08/25	1983	2100	0.47		
07/29	1984	2200	0.16		
05/28	1985	1900	0.87		
07/16	1986	2400	0.53		
07/30	1987	300	0.47		
06/29	1988	2300	0.50		
08/27	1989	2200	0.30		
06/27	1990	2100	1.00		

Townsend 12 ENE, MT 8329

Date		Time	Rain, in.		
07/19	1948	1400	0.35	Max =	1.00
05/21	1949	1600	0.28	Min =	0.20
06/15	1950	2100	0.77	years =	43
08/11	1951	1800	0.36		
07/19	1952	1600	0.27	Mean =	0.395
06/19	1953	1800	0.24	s =	0.172
06/26	1954	1900	0.45		
07/10	1955	2000	0.90	alpha =	0.134
07/02	1956	1800	0.22	beta =	0.318
06/15	1957	1500	0.32		
08/18	1958	1800	0.35	year	rain
08/31	1959	1500	0.34	2	0.37
08/01	1960	1200	0.24	5	0.52
09/01	1961	1500	0.20	10	0.62
07/14	1962	300	0.30	25	0.75
06/14	1963	1400	0.59	50	0.84
06/30	1964	1400	0.34	100	0.94
08/25	1965	1600	0.33		
06/30	1966	1700	0.30		
09/11	1967	1800	0.45		
12/30	1968	1200	0.60		
06/25	1969	1200	0.50		
09/19	1970	1900	0.20		
08/07	1971	400	0.40		
01/11	1972	2000	0.30		
08/04	1973	2100	0.40		
08/20	1974	100	0.40		
07/13	1975	2000	0.40		
08/04	1976	2100	0.60		
03/30	1977	1200	0.40		
07/03	1978	1800	0.50		
06/19	1979	500	0.30		
02/18	1980	1400	0.40		
07/07	1981	500	0.30		
08/18	1982	1800	0.30		
07/01	1983	2100	0.40		
08/31	1984	1800	0.30		
08/12	1985	1400	0.50		
08/31	1986	1500	1.00		
05/24	1987	1600	0.40		
09/10	1988	1600	0.20		
07/12	1989	1700	0.30		
06/10	1990	1700	0.30		

Utica, MT 8493

Date		Time	Rain, in.
07/12	1949	1900	0.48
07/15	1950	1200	0.84
08/22	1951	1700	0.87
08/10	1952	900	0.45
06/12	1953	1700	0.59
08/16	1954	1500	0.33
07/25	1955	1700	1.04
06/15	1956	1800	0.96
08/27	1957	1700	0.27
06/11	1958	1900	0.37

Max =	1.04
Min =	0.27
years =	10
Mean =	0.620
s =	0.283
alpha =	0.221
beta =	0.493

year	rain
2	0.57
5	0.82
10	0.99
25	1.20
50	1.35
100	1.51

Vananda 5 ESE, MT 8511

Date		Time	Rain, in.
07/11	1948	2200	0.55
05/31	1949	2000	0.46
06/08	1950	800	0.26
07/04	1951	1900	0.52
06/06	1952	2100	0.53
05/29	1953	600	0.85
08/05	1954	1600	0.49
05/23	1955	2100	0.28
07/03	1956	100	0.36
08/17	1957	2400	0.31
07/07	1958	2100	0.30
09/21	1959	700	0.43
08/06	1960	700	0.16
09/10	1961	400	0.25
06/14	1962	1800	1.45
07/17	1963	2100	0.74
07/03	1964	300	0.49
07/27	1965	1300	0.60
06/03	1966	2000	0.43
07/21	1967	2000	0.40
07/28	1968	2100	1.37
07/05	1969	2300	0.58
06/12	1970	1100	0.26
07/02	1971	1900	0.33
05/18	1972	2000	0.39
06/14	1973	500	0.50
08/20	1974	1300	0.45
06/16	1975	1400	0.35
06/06	1976	2000	0.40
05/15	1977	1300	0.25
09/12	1978	700	0.29
06/27	1979	1100	0.29
06/12	1980	2100	0.54
05/26	1981	800	0.39
06/06	1982	800	0.25
06/21	1983	700	0.49
08/02	1984	2000	0.35
08/28	1985	2100	0.82
08/31	1986	1900	2.10
05/19	1987	1800	1.50
06/12	1988	1800	0.90
05/28	1989	2400	0.60
05/24	1990	2100	0.30

Max =	2.10
Min =	0.16
years =	43
Mean =	0.548
s =	0.391
alpha =	0.305
beta =	0.372

year	rain
2	0.48
5	0.83
10	1.06
25	1.35
50	1.56
100	1.77

Westby, MT 8777

Date		Time	Rain, in.
07/20	1948	1500	0.55
05/30	1949	200	0.53
06/08	1950	1600	0.93
08/30	1951	600	0.94
07/01	1952	1500	0.77
06/30	1953	1500	1.03
07/26	1954	1000	0.78
08/13	1955	1700	0.40
08/06	1956	1300	0.49
08/12	1957	1100	0.39
06/18	1958	2100	0.18
06/10	1959	100	0.83
08/02	1960	1200	0.54
06/30	1961	200	0.43
08/10	1962	600	0.50
07/25	1963	300	1.11
07/04	1964	1400	0.39
08/05	1965	1600	1.60
06/04	1966	1500	0.35
06/11	1967	1900	0.20
07/10	1968	1800	1.25
07/23	1969	2000	0.40
07/27	1970	2200	0.51
06/14	1971	1600	0.65
06/08	1972	800	0.94
09/02	1973	1300	0.33
08/14	1974	100	0.41
08/18	1975	700	0.38
06/11	1976	2200	1.47
07/25	1977	2100	0.33
08/25	1978	1400	0.71
08/31	1979	1800	0.45
08/09	1980	2000	0.52
08/15	1981	600	0.62
05/28	1982	1700	0.57
08/28	1983	2200	0.42
06/22	1984	100	0.55
05/24	1985	2400	0.37
08/10	1987	1800	0.20
06/29	1988	800	0.30
10/26	1989	2200	0.30

Max =	1.60
Min =	0.18
years =	41
Mean =	0.600
s =	0.332
alpha =	0.259
beta =	0.451

year	rain
2	0.55
5	0.84
10	1.03
25	1.28
50	1.46
100	1.64

White Sulphur Springs, MT 8927

Date		Time	Rain, in.
06/28	1971	1500	0.40
07/18	1972	1900	0.30
05/25	1973	800	0.30
07/10	1974	2200	0.40
07/07	1975	800	0.60
09/18	1976	500	0.30
10/25	1977	2000	0.40
06/24	1978	1600	0.50
10/16	1979	700	0.30
05/23	1980	1400	0.30
07/24	1981	2200	0.60
07/09	1983	2000	0.30
09/21	1984	100	0.20
06/21	1985	1400	0.30
06/04	1986	2100	0.70
07/02	1987	1900	0.90
07/11	1988	1600	0.80
08/19	1989	1200	0.30

Max =	0.90
Min =	0.20
years =	18
Mean =	0.439
s =	0.200
alpha =	0.156
beta =	0.349

year	rain
2	0.41
5	0.58
10	0.70
25	0.85
50	0.96
100	1.07

Winnett 11 ESE, MT 9052

Date		Time	Rain, in.		
08/09	1948	1600	0.12	Max =	1.70
08/18	1949	1800	0.60	Min =	0.12
06/12	1950	1800	0.38	years =	43
08/29	1951	2400	0.58		
09/11	1952	2000	0.75	Mean =	0.509
08/04	1953	1400	0.39	s =	0.272
08/05	1954	1600	1.70		
07/06	1955	1600	0.53	alpha =	0.212
05/27	1956	1700	0.85	beta =	0.387
08/28	1957	1900	0.50		
07/03	1958	1000	0.34	year	rain
05/30	1959	1800	0.31	2	0.46
08/15	1960	2000	0.16	5	0.70
06/12	1961	1800	0.26	10	0.86
05/20	1962	2100	0.81	25	1.06
09/02	1963	1400	0.32	50	1.21
07/03	1964	100	0.34	100	1.36
07/08	1965	2100	0.43		
07/02	1966	2400	0.38		
06/13	1967	1500	0.29		
08/14	1968	2300	0.47		
06/21	1969	2100	0.58		
05/10	1970	2400	0.51		
08/30	1971	1200	0.45		
05/21	1972	200	0.74		
06/03	1973	600	0.27		
08/08	1974	800	0.47		
07/05	1975	2100	0.61		
07/21	1976	1400	0.54		
08/22	1977	2400	0.58		
05/23	1978	2100	0.75		
09/10	1979	1500	0.39		
06/11	1980	1800	0.50		
08/03	1981	600	0.81		
07/25	1982	800	0.93		
07/09	1983	2400	0.67		
08/02	1984	1600	0.22		
09/12	1985	1300	0.27		
08/31	1986	1400	0.48		
07/17	1987	2300	0.29		
09/18	1988	900	0.19		
06/09	1989	2000	0.44		
07/26	1990	1100	0.69		

Wolf Point, MT 9103

Date		Time	Rain, in.		
07/20	1949	1500	0.23	Max =	1.02
06/14	1950	2100	0.32	Min =	0.23
08/31	1951	1300	1.02	years =	10
07/19	1952	800	0.74		
06/23	1953	2100	0.85	Mean =	0.566
06/10	1954	1600	0.65	s =	0.248
07/06	1955	1900	0.40		
08/03	1956	900	0.55	alpha =	0.193
09/01	1957	500	0.42	beta =	0.454
06/07	1958	700	0.48		
				year	rain
				2	0.53
				5	0.74
				10	0.89
				25	1.07
				50	1.21
				100	1.34

* Wolf Point gage was not used in the analysis because the data is significantly lower than surrounding gages which have longer periods of record.

Yellowtail Dam, MT 9240

Date	Time	Rain, in.
08/04 1948	1500	0.22
09/02 1968	1300	0.20
08/15 1969	1800	0.60
05/21 1970	1600	0.63
08/08 1971	300	0.25
05/18 1972	1700	0.86
09/01 1973	800	0.31
07/02 1974	1600	0.57
07/22 1975	1700	0.40
08/01 1976	1500	0.76
06/12 1977	2000	0.81
05/02 1978	1900	0.59
08/27 1979	1500	0.30
08/16 1980	1600	0.40
07/25 1981	1600	1.50
06/23 1982	1600	0.60
08/09 1983	2300	0.30
06/17 1984	1800	0.70
07/30 1985	2100	0.20
07/09 1986	1500	0.60
08/24 1987	1900	0.40
05/07 1988	300	0.50
07/23 1989	1400	0.90
07/02 1990	1600	0.40

Max =	1.50
Min =	0.20
years =	24
Mean =	0.542
s =	0.294
alpha =	0.229
beta =	0.409

year	rain
2	0.49
5	0.75
10	0.93
25	1.14
50	1.30
100	1.46

Zortman, MT 9900

Date	Time	Rain, in.
09/13 1967	300	0.50
05/05 1968	1700	0.26
07/17 1969	1200	0.60
09/08 1970	100	0.40
06/18 1971	2200	0.31
04/16 1972	200	0.58
08/08 1974	900	0.70
08/07 1975	1400	0.38
09/17 1976	1600	0.28
08/20 1977	1700	0.15
09/07 1978	2300	1.20
04/07 1979	300	0.20
05/24 1980	2200	0.50
07/17 1981	1900	0.90
07/01 1982	1900	0.80
07/09 1983	2400	0.40
06/11 1984	1100	0.30
08/02 1985	400	0.70
06/29 1986	400	0.70
07/29 1987	2200	1.20
07/03 1988	200	0.60
05/08 1989	1400	0.60
05/24 1990	2000	0.50

Max =	1.20
Min =	0.15
years =	23
Mean =	0.555
s =	0.282
alpha =	0.220
beta =	0.428

year	rain
2	0.51
5	0.76
10	0.92
25	1.13
50	1.28
100	1.44

Warmarth MDU Co, ND 5575

Date	Time	Rain, in.
09/12 1950	1500	0.18
08/24 1951	2200	1.10
08/18 1952	1300	1.18
08/28 1953	2300	1.40
08/15 1954	2400	1.40
07/06 1955	100	1.04
08/02 1956	1700	1.35
09/04 1957	1700	0.69
06/08 1958	1900	1.05
06/25 1959	2200	1.10
05/27 1960	1900	0.55
07/30 1961	100	1.66
06/11 1962	1600	1.03
06/05 1963	2000	0.92
06/07 1964	2200	1.30
06/25 1965	2000	0.95
07/12 1966	1600	1.11
04/12 1967	2200	0.51
08/18 1968	1100	0.30
07/03 1969	1800	0.70
07/23 1970	800	1.30
06/05 1971	700	0.90
06/25 1972	1400	0.80
05/19 1974	2200	1.20
06/25 1975	2100	0.50
06/05 1976	2000	1.20
06/14 1977	1600	1.80
08/16 1980	1300	0.60

Max =	1.80
Min =	0.18
years =	28
Mean =	0.994
s =	0.390
alpha =	0.304
beta =	0.818

year	rain
2	0.93
5	1.27
10	1.50
25	1.79
50	2.00
100	2.22

Trotters 3 S, ND 8812

Date	Time	Rain, in.
08/12 1950	600	0.40
08/24 1951	2100	0.43
07/19 1952	1700	0.87
08/19 1953	100	0.65
06/13 1954	1400	1.40
06/26 1955	1300	1.03
08/03 1956	1800	0.71
09/01 1957	1500	0.60
06/07 1958	600	0.39
06/26 1959	1900	1.55
06/20 1960	1800	0.95
06/29 1961	1900	1.29
08/10 1962	1500	1.22
07/07 1963	200	0.63
06/14 1964	2000	0.98
06/25 1965	1900	0.54
07/02 1966	1700	0.86
06/18 1967	1200	0.87
07/22 1968	1500	0.65
06/06 1969	1600	0.72
07/13 1970	2100	0.54
06/13 1971	1800	0.40
07/27 1972	2100	0.65
09/01 1973	1100	0.41
06/21 1974	100	0.70
08/14 1975	1200	0.64
06/22 1976	2400	1.03
06/14 1977	2000	0.50
06/29 1978	900	1.20
07/11 1979	1700	0.40
06/13 1980	100	0.80
08/04 1981	2000	0.40
07/26 1982	1800	0.50
07/18 1983	200	0.80
06/20 1984	2200	0.70
08/02 1985	1900	0.40
07/17 1986	200	1.00
06/16 1987	1800	0.40
09/18 1988	1200	0.20
07/17 1989	1200	1.00
05/25 1990	400	0.50

Max =	1.55
Min =	0.20
years =	41
Mean =	0.730
s =	0.313
alpha =	0.244
beta =	0.588

year	rain
2	0.68
5	0.95
10	1.14
25	1.37
50	1.54
100	1.71

Williston WBO, ND 9425

Date	Time	Rain, in.		
05/17 1949	1500	0.77	Max =	2.27
06/12 1950	600	1.03	Min =	0.24
08/19 1951	1700	0.66	years =	42
07/19 1952	2100	0.63		
07/10 1953	2100	0.57	Mean =	0.805
08/26 1954	2100	0.69	s =	0.457
06/28 1955	100	0.82		
06/18 1956	1500	1.04	alpha =	0.356
07/22 1957	1300	0.43	beta =	0.599
06/03 1958	2300	0.29		
06/20 1959	500	1.20	year	rain
06/19 1960	2300	1.49	2	0.73
07/27 1961	2200	0.54	5	1.13
07/06 1962	100	1.29	10	1.40
07/10 1963	500	2.27	25	1.74
07/05 1964	500	1.36	50	1.99
06/30 1965	2300	0.58	100	2.24
07/01 1966	300	0.40		
07/07 1967	200	0.56		
06/10 1968	600	0.41		
07/07 1969	1700	0.56		
06/12 1970	1700	0.96		
07/09 1971	2200	0.93		
08/14 1972	300	2.02		
04/20 1973	1500	0.24		
06/09 1974	1600	0.89		
08/07 1975	1900	0.49		
06/07 1976	300	0.54		
05/17 1977	1900	0.94		
07/04 1978	300	1.04		
06/27 1979	1500	0.58		
09/11 1980	1900	0.30		
05/31 1981	2300	0.53		
06/27 1982	2300	0.72		
07/10 1983	100	0.50		
09/12 1984	100	0.63		
07/18 1985	200	0.37		
07/17 1986	200	1.35		
07/18 1987	1200	1.65		
06/29 1988	2400	0.49		
07/11 1989	1900	0.44		
05/25 1990	1100	0.61		

Camp Crook, SD 1294

Date	Time	Rain, in.		
06/25 1975	2000	0.35	Max =	1.40
08/13 1976	1800	0.50	Min =	0.30
09/30 1977	1100	0.30	years =	16
07/18 1978	2100	0.65		
07/04 1979	1200	0.30	Mean =	0.607
05/29 1980	1400	0.85	s =	0.357
06/03 1981	1900	0.49		
08/19 1982	2100	1.12	alpha =	0.278
07/27 1983	2000	1.26	beta =	0.446
06/20 1984	1900	0.31		
05/28 1985	1800	0.39	year	rain
07/27 1986	1400	0.39	2	0.55
07/22 1987	1200	0.40	5	0.86
05/30 1988	2100	0.50	10	1.07
07/13 1989	2100	1.40	25	1.34
07/19 1990	2100	0.50	50	1.53
			100	1.72

Ladner, SD 4671

Date		Time	Rain, in.
09/03	1951	2300	1.14
07/19	1952	1700	0.70
06/19	1953	100	1.00
06/27	1954	1800	0.60
06/27	1955	1900	1.33
07/02	1956	1500	1.08
08/22	1957	1000	0.61
06/04	1958	1600	0.68
07/15	1959	1500	0.49
06/08	1960	2400	0.97
07/31	1961	1600	0.48
07/16	1962	1600	1.75
09/03	1963	800	0.70
06/14	1964	1800	1.15
05/23	1965	1800	0.53
08/06	1966	1300	1.21
06/25	1967	1500	0.99
07/17	1968	1500	1.68
07/15	1969	1700	0.96
05/07	1970	1700	1.22
06/04	1971	1400	0.58
07/22	1972	100	0.84
07/22	1973	1400	0.40
07/03	1974	900	0.45
06/08	1975	1500	0.44

Max =	1.75
Min =	0.40
years =	25
Mean =	0.879
s =	0.378
alpha =	0.295
beta =	0.709

year	rain
2	0.82
5	1.15
10	1.37
25	1.65
50	1.86
100	2.07